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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The Factory Report Analysed

In a recent issue we gave abstracts from the Annual Report of the Chief Inspector of Factories and Workshops for 1935, and it now seems desirable to pass in review some of its more important disclosures. In the metal founding trades there were 8,896 non-fatal injuries reported last year, and 30 injuries which were fatal. The last figure is confined to adult males. Of the non-fatal accidents, 165 were sustained by adult women, 1,337 by youths and 92 by young girls. The highest group of deaths, nine, were due to handling goods or articles in manufacturing or carrying processes not included in the categories which will be dealt with below. Seven died through injuries received from falling bodies, and a further six through themselves falling down. Lifting-machinery accidents were responsible for another three, and individual fatal accidents were due to (1) shafting; (2) railways; (3) electricity; (4) molten metal, and (5) not classified. Out of the thirty fatal cases within the industry *six—or one-fifth—were due to sepsis.* This does certainly emphasise the need for an efficient first-aid service to be maintained in the foundry industry as it has the highest number of deaths of all the more important sections of industry. This state of affairs is emphasised by the analysis of the non-fatal accidents, for herein it is revealed that of the 8,896 non-fatal accidents, sepsis was recorded in 796 cases. There is much food for reflection in the fact that, whilst 1,798 cases of molten-metal burns were recorded, no less than 1,099 persons were injured through falling bodies. Surely this latter figure at least could be brought down to more reasonable proportions. There has been no reduction in deaths from dust diseases, and between them the grinding of metals and sand blasting have accounted for 150 deaths during the year.

One of the most interesting sections of the Report is that prepared by the senior medical inspector, Dr. John C. Bridge, who confirms the age-old adage that "hard work never hurt anyone," by stating "Industry has undoubtedly been more active, but the general health of the workers, so far as can be at present judged, has not been adversely affected." It is interesting because he gives a very broad hint that the time is now ripe for emending the conditions of employment for young persons. It seems that the last legislation was thirty years ago. The inspector states that better transport facilities may encourage longer journeys to and from work, and that the hurry and bustle of modern manufacturing conditions are disadvantageous to youth. He indicates that the hours of employment should be *substantially* less than those permitted by the existing legislation. So long as another equally old adage—"Satan finds some mischief, etc."—is borne in mind and carried out in practice, no great damage will be done.

The Second Session

As we have indicated previously, the second session of the British Foundry School opens on September 21. For the benefit of those founders who have not followed previous announcements, we may be excused for stating that the object of the School is to provide full-time instruction for one year to men of suitable attainments and who, having had foundry experience (whether in cast iron, malleable iron, steel or the non-ferrous metals), show capacity for senior responsibilities as foundry engineers, metallurgists or managers. The School aims not at teaching practical founding, which can only be learned in the foundry itself, but at equipping the founder with that background of knowledge, of principles, of practice, of equipment, of material, which is becoming increasingly necessary to success. The fee for the course is £30, and in addition to the permanent staff, specialised lectures were given last session by some seventy experts.

The pass list showing the award of the School's Diploma after the work and examinations of the first session reveals that there are four subjects in the examination. The written Papers concern Foundry Metallurgy, Foundry Technology (that is, all that concerns materials, plant and equipment in the industry), and Foundry Management. In the practical work, described as Foundry Planning and Casting Studies, the student is expected to prepare, either for a given steel casting or a grey iron casting, a complete scheme of production, from the pattern to the time of delivery. In addition he has to do the same for a non-ferrous casting in, say, a brass, bronze or aluminium alloy, or, alternatively, plan a foundry for a given output or modify an existing foundry to suit specified requirements. This practical work takes nearly twice as long as all the written Papers put together. While it is difficult to spare a man for a year, foundry owners and directors would be well advised to consider whether the inconvenience would not be more than repaid later.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

A Few Stray Thoughts

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Some years ago at an I.B.F. Conference an original and very instructive Paper was given by Mr. Ben Hurd on "The Effect of Coal Dust on Casting Surfaces," showing, by some unique photographs, how the fuming effect of the burning coal dust produces the "often sought after" blue casting skin which is always a joy to the foundrymen's eye.

During the ensuing discussion, Mr. J. M. Primrose of Falkirk got up and literally dropped a bombshell by asking: "Why do we want a blue skin, seeing that all castings' surfaces are eventually painted or enamelled, or in a short time will rust, and also buyers of castings have never been known to pay more for castings having a blue skin?"

Still quoting Mr. Primrose: "If a blue skin were an asset, why stop at blue, why not experiment with producing green, red or yellow and make a complete colour scheme?"

These remarks, by the way, were made in all good purpose to cause a healthy discussion, and were purely "provocative."

At the present time one cannot help thinking when reading the results of researches and investigations on cast iron being carried out all over the world that the majority of the brains, energy and money is being spent on making additions of expensive alloy metals to cast iron, all making claims of miraculous physical properties and a "cure all" for the troubles which beset the foundryman. One wonders if it is not time that someone dropped a similar bombshell to that of Mr. Primrose, and asked "What is the matter with ordinary cast iron?"

One of the complexities of cast iron is that it is made up of so many different constituents which all have a varying effect on the iron and on one another; even yet the full effect of these constituents is not thoroughly known. One might ask: "Why add other constituents to join in the medley? Isn't it rather like adding more dogs to a dog fight?" All the energy seems to be spent in a similar way, namely, that of making cast iron more complex, and, what is more serious, very much more expensive.

Are we not suffering from the "machine age" complex of grasping anything, regardless of cost, which makes it easy to produce, or taking the "line of least resistance" regardless of whether the "game is worth the candle" and without a thought as to whether the same result could not be obtained by mixing a little "brain" with ordinary cast iron? After all, do these additions perform all they claim? If we speak the truth we are inclined to say *No*! Are we not working in the wrong direction and would it not pay to use our energies in trying to make ordinary cast iron better, and even cheaper? A terrible thought, some might say, especially to the makers of special irons, but after all it is from good castings produced at a competitive price that we earn our living.

Production costs are getting down to rock bottom and the metal of which castings are made is the only thing left to cheapen in the race for lowering costs and expanding the market for cast-iron castings. Surely, with all the brains we have available in the trade and technical associations, something can be done in this direction?

A short time ago we heard and read a lot about the "graphite nuclei" theory, which seems to have been dropped for the latest "non-metallic inclusion" theory. One is apt to ask, "Are we right in dropping the graphite nuclei theory? Is there not something in each theory and is not the whole secret of a stronger cast iron wrapped up in these two ideas?"

Why is it that by mixing a small amount of high silicon ordinary iron with a large amount of ordinary white from separate cupolas, the physical properties are better by at least a third of that which would be obtained from an iron of the same analysis cast from one cupola? Still ordinary cast iron, mark you, with no expensive additions, but a better iron at a cheaper price. This is very simple, you say. Of course it is, so simple that all but a small minority have not seen it, not being able to see wood for trees. The only reason for this seems to be that we are too convinced that it is not possible to make cast iron better without making it more expensive.

Why is it not possible to produce ordinary cast iron to give 20 tons tensile? Surely, if we think, there is no reason.—Yours, etc.,

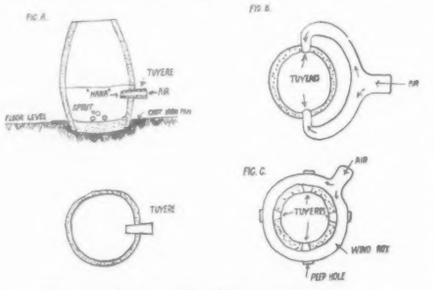
"DIVES."

Japanese Foundry Practice

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—As an appendix to my notes on the unique features of the cast-iron industry of Kawaguchi, published in your Annual Review Number, I enclose a sketch of the "Koshiki" furnace as used at Kawaguchi, which was drawn in 1818.

The "Koshiki" of those days (Fig. A) was composed of two segments, upper and hearth parts, with only one tuyere in one side. Its sectional view is roughly sketched above. The tuyere was stretched out inside the lining, which was made of refractory clay and called "Hana" (literally nose). Varying with the prevailing climate, winter or summer, fair or rainy, its inclination was regulated.



FIGS. A TO C.—DEVELOPMENT OF "KOSHIKI" FURNACE.

The next improved type of "Koshiki," which was in use up to about 1900, had two tuyeres diametrically opposed to each other (Fig. B). The present type was then introduced by a modification of the normal European cupola construction (Fig. C).—Yours, etc.,

R. MAEDA.

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Tokio Imperial University,
Tokyo, Japan.

Cricket Match

(Institute of British Foundrymen *versus* British Works Managers' Association).

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I should like to take this opportunity, through the courtesy of your columns, of conveying my thanks to those who played in the cricket match on behalf of the Institute, and those visitors whose presence served to inspire our team to win the Lichfield Bridgeman Trophy.

I imagine that you will be devoting some portion of your issue to a description of the match, and for this reason it will be unnecessary for me to do anything more than ask you for this opportunity of conveying my thanks.—Yours, etc.,

J. E. HURST (Past-President,
Institute of British Foundrymen).

"Ashleigh,"
Trent Valley Road,
Lichfield, Staffs.
September 14, 1936.

Outlook for Tin

By "ONLOOKER"

During the past few weeks tin has enjoyed a respite from the disturbing fluctuations which have characterised this market for the greater part of the present year, and which have done much to shake the confidence of all concerned with this metal. Consumers, perhaps the first to take alarm, promptly adopted a cautious policy of hand-to-mouth buying from which they have only departed on one or two occasions, notably when American users bought freely at what proved to be practically the bottom of the market. In the United States the tinplate mills have been very busy and are still running at a high percentage of capacity, while in this country too we cannot complain of lack of orders. The fact is, of course, that the situation got out of hand, for reserves in this country fell to vanishing point and it was necessary to adjust the output quotas rapidly to deal with this difficulty. The price suffered in consequence until at one time it looked as if the bottom would really fall out of the market. Fortunately, matters have mended and there is now more confidence all round.

Among the producing countries Bolivia and Siam have been well in the limelight, the former owing to the problem of dealing with arrears of shipments and the latter through the dispute which has arisen over the amount of the quota to be allotted. At the time of writing no settlement has been reached, but a meeting of the Committee has been called for September 23, after which perhaps it will be known more clearly what the future holds. The doubt which overshadows the situation is due to the uncertainty surrounding the continuation of the curtailment plan during next year, and, although everybody seems fairly confident that differences will be composed and agreement finally achieved, no one is disposed to take a decisive step until a decision is actually reached.

The Siamese Position

It seems to be generally expected that the negotiations are bound to be rather protracted, for Siam is in a fairly strong position and is not likely to give way readily. On the other hand, it is unlikely that the Siamese adviser will drive too hard a bargain, for the existence of the curtailment pact and quota arrangement has made it possible to maintain the price at a level sufficiently favourable for Siam to build up a really flourishing industry. Agreement will probably be reached eventually and it is doubtful if Siam will have to give way to any great extent.

The Other Producers

In view of this position, which approaches an *impasse*, it is pertinent to ask whether consumers are justified in distrusting the present price level. At the time of writing the quotation is above £196 and looks like struggling a little higher, but it can be taken for granted that any adverse news regarding the progress of negotiations would bring about a sharp reaction. The tin market has latterly been under the influence of prevailing bullish sentiment and the advance has certainly discounted all favourable factors. If Siam gets her way the fashion will be set for high quotas, and that presupposes a continuance of the scheme on the basis of a high all-round rate of output under which stocks would increase and the quotation inevitably suffer. Apart from the combined production of the four signatory countries it must be remembered that Siam, the Belgian Congo and China between them have a capacity which cannot lightly be ignored, and in addition there is a number of smaller outputs which tend to increase when the price keeps anywhere near £200. If restriction is to continue £190 seems to be about a top limit for the quotation, but if the scheme breaks down or is modified then the market is likely to lose ground rapidly.

Development of Control in Electrodeposition Processes*

By A. W. HOTHERSALL, M.Sc.

The electrodeposition process consists of two main stages. First of all, the article, which may have been polished if it is to receive a decorative coating, has to be freed from all traces of grease, dirt or oxide. Secondly, it is immersed in the plating solution, which contains a salt of the metal to be deposited, and a direct electric current is passed through the solution, the article being connected to the negative pole. A coherent metal film is gradually built up and when sufficient thickness of metal has been deposited, the article is removed, washed, and, if necessary, is again polished to achieve the required finish. The quality of the coating and the cost of the process are determined by the control of the two stages of cleaning and deposition.

Cleaning before Electrodeposition

In pre-War times, methods of cleaning generally used were inefficient in a chemical sense; they depended chiefly on individual hand scouring with a wet brush dipped in finely-divided powder such as lime or pumice.

To enable the process to be speeded up, it was necessary to eliminate hand treatment. Laboratory studies of the mechanism of the cleaning of metals in aqueous solutions showed that mixed cleaning solutions could be devised which would effectively remove grease and dirt. The process was hastened by passing an electric current through the solution: the scouring action of gas bubbles which are liberated at the surface of the metal helps to dislodge the grease and dirt. The efficiency of the cleaning process was further improved by the development of an ingenious apparatus in which the majority of greasy matter can be washed off by the condensation of the vapour of an organic solvent, thus lessening the quantity of matter to be removed in the aqueous solution.

The complete removal of all impurities from the surface of the metal is essential if continuous and adherent coatings are to be produced. The importance of choosing a solution of suitable composition can be realised when it is known that certain substances, of which gelatine is an example, adhere so strongly to metals that they cannot be rinsed off and their presence, in the form of a thin invisible film, will prevent the firm adhesion of the deposit.

Adhesion

In decorative plating, a very high degree of adhesion between the coating and the underlying metal is not generally regarded as essential, but certain engineering applications of electrodeposition depend for their success on the coating remaining adherent under heavy stresses. Investigation of adhesion has revealed interesting facts and has led to remarkable practical results. For the strongest adhesion, not only must all grease and dirt be removed, but also the surface of the basis metal must be dissolved away. Mechanical treatments applied before plating to give the metal the required shape and surface finish, for example, rolling, machining, polishing, etc., weaken the surface layer and often render it specially susceptible to embrittlement by hydrogen evolved during plating. Removal of a thin surface layer of the metal by etching has been found greatly to increase the difficulty in detaching the deposit, so much so that the coating may be regarded as forming an integral part of the article. Using the controlled methods of etching now available, it is possible to build up a thick nickel deposit on the flat end of a steel rod, which would require a load of over 20 tons per sq. in. to detach it.

The modern electrodeposition process thus enables working parts of machines which are locally worn to be restored to size by building-up, and also renders possible other engineering applications of electrodeposited metals in which the coating is subject to high stresses.

Electrodeposition

Turning to the electrodeposition process, the general tendency has been towards a simplification of the complicated baths used in the early days of the industry. With the development of more precise methods of control, it became possible to determine the function of the individual constituents of the solutions and to improve and simplify the formulæ on rational lines. By these means the rapidity of the process was greatly increased, so that whereas a nickel coating of good quality required some 3 to 4 hrs. for deposition 30 years ago, the same thickness of metal can now be formed in 30 to 40 minutes, or even less.

In the developments which have taken place attention has been chiefly focussed on nickel deposition, since coatings of nickel form the foundation of the majority of chromium coatings plated to-day.

Control of Acidity

The most important method of control applied by the chemist to plating solutions is the precise measurement of effective acidity, which is expressed by the symbol *p*H. In the early days of nickel plating solutions were usually controlled by two test papers—litmus and congo red. Judged by modern standards this represented only crude control, and with the simple methods now available the plater can control the acidity of his solution to much finer limits. It is interesting to note that the *p*H of nickel-plating solutions can now be determined fairly accurately by means of a strip of test paper, thus combining the simplicity of the old method with the accuracy of the new one. With the introduction of the *p*H method of testing, many of the vagaries in the behaviour of nickel-plating solutions disappeared and more consistent results were obtained: furthermore the investigation of the causes of defects in nickel deposits became profitable.

Control of Defects in Deposits

The tendency of nickel plating to crack and peel is due to the stress in the deposit which varies with conditions of deposition, such as acidity and temperature, and is increased by certain impurities. The stress may be minimised by a proper control of these conditions and by the use of suitably pure solutions.

The causes of other defects, such as pits which are produced by the adhesion of gas bubbles to the surface during plating, have also been investigated and remedies have been found. Here again, the precise control of acidity, supplemented by other chemical and physical methods of testing which will be referred to later, has proved of paramount importance in enabling the effect of impurities and the function of the different constituents of the bath to be determined.

One disability of the plating process, which has been reduced in importance as a result of laboratory investigation, is the tendency to unequal distribution of deposit, especially on articles of uneven shape; this tendency is expressed as the "throwing power" of the solution. An example is recorded in which a deposit was four times as thick in one position as in another on the same article. A knowledge of this disability has enabled designers to improve the shape of articles intended for plating: an investigation of its causes has revealed the factors responsible and has led to improvements in the composition of plating solutions whereby the distribution of deposit can be improved.

Control of the Protective Value of Electrodeposited Coatings

Side by side with these developments, studies of the protective qualities of deposits have been pursued. Thirty years ago, when impure nickel anodes containing 6 to 10 per cent. iron were employed—because pure nickel anodes would not dissolve in the solutions then used—it was thought that the rusting of nickel-plated steel was due to the high iron content of the coating. Later when solutions had been modified to allow pure anodes to be used generally, rusting was still experienced. It was not until chemical tests of the continuity of electrodeposits came to be applied that it was found that the rusting, which was liable to take place on steel plated with nickel and certain other coatings, was due to pinholes in the coating. The development of reliable tests for determining the presence of pinholes accurately has gone far towards helping to enable the fundamental causes of this defect to be determined. Whilst this work is not yet finished, it has been definitely established that there is a relationship between thickness and the number of pinholes in the coating and that, if they are made sufficiently thick, most electrodeposits can be made free from pinholes. This limiting thickness varies with the metal being plated and the quality of the basis metal: thus, tin deposits, to be sound, must usually be greater than 0.0005 in. thick, while nickel deposits are not usually completely sound unless more than about 0.0015 in. thick. Examples of nickel coatings of this order of thickness, representing a high standard of quality, may be found on certain British motor cars now being produced.

The importance of having an adequate thickness of the more reactive coatings such as zinc and cadmium has also been shown by corrosion tests which have demonstrated that these metals progressively waste away when exposed in industrial atmospheres.

Thus it is now generally established that electrodeposited coatings of high protective value can be obtained commercially and that the thickness of the coating provides in most cases a reliable index of its quality. Very recently, a simple and accurate chemical test has been developed whereby the thickness of coatings of nickel, copper, bronze, zinc, and cadmium can be determined at any desired point on an article in the course of two or three minutes. Details of this test will shortly be made available; it is now mentioned to show that the way is paved for a standardisation of coatings in terms of their quality.

Structure and Properties of Electrodeposited Coatings

The developments in the control of the plating process described have referred chiefly to the results of applied research on specific problems. Results of considerable practical importance have also been obtained from investigations of a more fundamental nature.

In most of the applications of electrodeposition which are familiar to the public, the structure and mechanical properties of the deposit may be varied over a wide range with little effect on the behaviour of the coating in service. Nevertheless, the development of methods by which the structure and properties of deposits can be studied is of great importance in pro-

* A Paper read before the meeting of the British Association for the Advancement of Science in Blackpool last week.

viding a picture of the way in which the structure of the deposit is built up: the knowledge obtained in this way is invaluable in giving an insight into the function of the different constituents of a plating solution and in enabling methods of control on sound lines to be built up.

Early investigations of the structure and properties of electrodeposits were made chiefly with copper, partly because its deposition was fairly easily controlled and partly because of the considerable commercial interest in heavy copper deposition about this time. Microscopic studies and quantitative measurements of the properties of deposits began to be developed and applied on sound metallurgical lines from about the beginning of the present century. The theories evolved, however, broke down when they were applied to nickel and metals which are deposited together with hydrogen. Hence, a strong body of opinion was formed which attributed to hydrogen gas, or to the formation of hydrides, the controlling factor affecting the structure of these deposits. Recently, however, considerable advances have been made which have clarified the position.

These advances have partly resulted from the application of quantitative methods of studying the properties of deposits prepared under carefully controlled conditions, and partly from the work of the physicist who has applied *X*-ray and electron-diffraction methods to a study of the inner structure of electrodeposits. It is now widely held that the normal tendency is for a deposit to grow into large crystals but that the crystal growth is interfered with by the inclusion in the deposit of minute quantities of colloid particles or of complex ions. Thus the continued growth of a crystal may be prevented and in the presence of considerable interference the deposit may consist of very small grains having no definite structure under the microscope. It should be emphasised that considerable interference may be produced by very small concentrations of certain substances: one part of certain colloidal substances in a million parts of solution will profoundly modify the structure and properties of copper deposits, for example.

It is thus possible to secure deposits having a wide range of physical properties by a modification in the composition of the solution used. Very fine grained deposits usually have abnormal properties which cannot be obtained in the metal by any method other than electrodeposition. Thus, the hardness of electrodeposited chromium can approach 1,000 on the diamond pyramid hardness scale—a value in excess of the hardest steel; in this condition the deposit will cut glass. Cast chromium, on the other hand, is soft like copper. Nickel, copper, and many other metals can also be electrodeposited in a harder condition than is achievable by any mechanical methods of cold working, such as rolling. Furthermore, the hard deposits sometimes have a degree of ductility which is higher than would be anticipated from the properties of cold-worked metals. Thus there is an increasing use of electrodeposits for engineering and other special purposes, where advantage can be taken of the chemical or of the abnormal mechanical properties of the metal. Under certain conditions, the chemical properties of the deposit may be different from those of the pure material. Thus it has been found possible to deposit silver of a golden colour from iodide solutions. In this form the deposit is said to be more resistant to tarnish than the pure material.

In addition to their effect on mechanical and chemical properties, certain substances if present in the solution cause the deposit to have a lustrous appearance. Investigation has resulted in the development of commercial processes for depositing nickel, silver, tin, cadmium, and zinc in a lustrous condition similar to that produced by mechanical polishing. This development promises to have a considerable effect on the electroplating process and may extend its application in certain directions.

Random Shots

"Marksman" arrived at Lichfield on Sunday with no light heart. You may remember that he had arranged for Mr. K. B. E. Frizzle, the well-known cricket commentator, to record in this column his impressions of the match between the Institute of British Foundrymen and the Works Managers' Association. But on the day before The Day, that gentleman had stowed aboard the "Orion," and so was not available. However, it's an ill wind that blows nobody any good, and the delinquency of Mr. Frizzle gives "Marksman" the opportunity—and the pleasure—to publish the following account of the game by one of the members of the fair sex who turned out to cheer the foundrymen to victory.

* * *

King Edward VI School cricket ground, Lichfield, was the site, September 13 was the day, 2.30 p.m. was the time, and the mortal combat was between the Institute of British Foundrymen and the British Works Managers' Association (Birmingham Branch). It was not a day for ducks, for the sun was shining brightly (we want to thank all members who so kindly prayed for us on Saturday). One of the two deserters in the foundrymen's camp (Oh, that I should have to record such foul deeds)—that inimitable fast bowler, Jack Gardom, was missing; but, like the proverbial bad penny, he arrived in time to play for the Works Managers. Jimmy Hurst (was it the heat, that inevitable camera or his monocle?) installed Lennox Holt as Captain of the I.B.F. team, and that worthy member was immediately weighed down with the great responsibility. The I.B.F. lost the toss and the W.Ms. decided to do or die and bat first. Lest it be thought that this cricket match was not a very serious affair, let it be said that there were two umpires and a scorer!

* * *

The opening pair for the W.Ms., Aldrich and Sadler, were determined to show that it was not the first time that they had worn those gleaming cream flannels. I overheard one enthusiast remark that the I.B.F. had no slow bowlers. Why worry about slow ones when we have fast bowlers like Lennox Holt, F. W. Russell, J. R. Shotton, and L. D. Drake? An hour after the start, the score was 10 runs for 2 wickets, and the immaculate W.Ms. were still standing in the pavilion and beaming broadly. How little they understood the foundrymen's tactics. The Institute dismissed five members of the opposing side for 35 runs. Oh, those glorious catches!—I.B.F. members must have been practising with oranges, tutored by small sons, for weeks beforehand. Then the W.Ms., captained by W. Todd, sent in Jack Gardom, who took his position amidst the weeping and gnashing of teeth of the I.B.F. supporters. Not for long, however, was he allowed to wield his bat against his comrades, for after breaking his "duck" Lennox Holt got him out l.b.w. (The umpire must have been a very brave man.) By 4.30 they were all out for 52 runs and there was a general adjournment for a welcome tea in the pavilion. If your neighbour happened to belong to the opposition, you offered him a cucumber sandwich and a bun, but a fellow supporter was regaled with tomato sandwiches and French pastries.

* * *

Duly refreshed, the teams took the field again and even the hens cackled their appreciation from one corner of the field. But the foundrymen did not have it all their own way, for the W.Ms. made good use of their crack bowlers—what a pity the Test team has been chosen; and one of the fielders at least had "refreshments" brought to him on the field—yes, you guess right! The umpire for the I.B.F., Dr. G. H. Froggatt, of Sheffield, caused great sensations by conveniently turning away at critical moments, and I am afraid that we shall hear more about that. J. R. Shotton was the hero of the day, for he scored a very helpful 19 runs and survived A. C. Tunley, J. Cooke and L. D. Drake. All proved that they knew how to score runs, and the two youngsters in the team—George Lunt and Dalton Hurst—played manfully and showed that they were the worthy sons of foundrymen. Result—all out for 89 runs and the match won by the Institute of British Foundrymen. Three cheers for the W.Ms.

* * *

Jimmy Hurst then did his stuff and remarked how many a goodly joust had taken place on that very ground and much blood had been shed and how he hoped that this cricket match would become an annual event (and so say all of us). He then called upon Mrs. Hurst to present the trophy, which is a gargoyle off the original Lichfield Cathedral which Councillor J. H. Bridgeman, of Lichfield, had kindly presented, and which can never be won outright, and is to be called the Lichfield Bridgeman Trophy. I believe Mr. Roy Stubbs undertook to deliver this new trophy to Mr. Makemson at the head offices in Manchester, where it will, no doubt, occupy a position of honour. The members of the losing team were each presented with a lollipop as a souvenir of the Match.

* * *

The parties then returned to the George Hotel for dinner and . . . . well there is no need to record their doings, for we all know that members of the I.B.F. behave themselves wherever they go. Players and spectators alike wish to tender their sincere thanks to the Rev. R. W. Clarke for his kindness in lending the school cricket ground, the use of the bats, etc., and the facilities which the school offered for changing and parking of cars. Also to those who organised this jolly cricket match, which I am sure we all enjoyed—thank you very much and here's to the next time!

* * *

THE SCORE SHEET

B.W.M.A. (BIRM. BRANCH)	Runs
Aldrich, run out	0
Sadler, b. Cooper	9
Baugh, c. Cooke, b. Russell	2
Franks, c. Drake, b. Holt	12
Mallinson, b. Holt	12
Gardom, lbw. b. Holt	1
Todd, c. Cooper, b. Shotton	5
Heap, b. Drake	0
Parkin, b. Cooper	8
Shearer, b. Shotton	1
Isaacs, not out	1
Byes	6
Total No. of Runs	52

I.B.F.	Runs
Tipper, b. Sadler	0
Bell,lbw. b. Aldrich	8
J. Cooke, c. Heap, b. Sadler	11
Cooper, b. Aldrich	0
Russell, b. Sadler	0
Shotton, lbw. b. Sadler	19
Holt, b. Sadler	0
Pincott, c. wicket, b. Gardom	6
Drake	10
Tunley	15
George Lunt	3
Hurst, not out	1
N. Cooke	0
Byes	16
Total No. of Runs	89

Cast-Iron Die-Castings

The production of pressure die-castings in cast iron is said to have been placed on a commercial footing by the introduction in America of the Wetherill process, which is described by Charles O. Herb in "Machinery" (N.Y.). The problem of die erosion is tackled by using cast-iron dies fitted with liners which are made from cold-rolled sheet steel, are able to contract and expand freely, and, besides being conveniently replaced, are relatively inexpensive. The cast iron is melted in a rotary oil-fired furnace, from which it is charged in batches into a special closed crucible. An air pressure of 20 lbs. per sq. in. is then applied to the surface of the molten metal, which is thus forced up a silicon-carbide sleeve, heated at its top end, and then into the dies which are mounted above the crucible. Pressure is maintained for about 45 sec., after which the molten iron still in the gates, nozzle, and sleeve runs back. Fine-grained castings, free from blowholes, and having enhanced mechanical properties, are obtainable to dimensional tolerances of ± 0.005 in., and can be made not only in foundry iron but also in special nickel and silicon irons.

The Complex Interdependence of the Properties of Light Alloys*

By R. de FLEURY and H. PORTIER

[*Abridged.*]

All metallurgists in contact with manufacture are aware of the many apparently unrelated factors which are brought to light during experiments with new alloys, new processes, or new tests. In addition to the problems involved in the pursuit of improved properties, in meeting more rigid tests, in the perfecting of manufacturing technique, or imposed by the design and dimensions of the article, either in the foundry or in use, there are the more general but less evident troubles which intervene unexpectedly, in a manner at once more deceiving to the founder and more dangerous to the user, since they are difficult to trace and are often aggravated by apparently logical remedies. In the interpretation of an incident of either fabrication or functioning, both direct and indirect factors should be considered; better still, they should be foreseen by the management from a continual analysis of the facts of production.

Method of Classifying Factors

Observations made by one of the authors, over many years, led him to classify the various factors even before defining them, according to Table I. The direct factors are revealed by existing knowledge and experience. It is the less apparent factors that are mainly to be considered, for it is impossible to foresee what may be the indirect repercussions of a remedy applied as the result of an error in diagnosis. It is wrong to classify remedies in the same way as the factors to which they correspond, since, for example, a remedy for a direct factor (1-C) can have disastrous consequences in introducing a new indirect (2-C) or even unrecognised factor (3-C). In the closed cycle comprising the various stages in the life of an article, from its entry to the foundry as raw material to its return as scrap, a number of factors intervene, which appear to be unrelated, but which are actually so interdependent that a simple modification of one can upset or re-establish the equilibrium of the whole cycle.

TABLE I.—*Classification of Defects.*

Influence of the factors.	Elucidation of the factors.		
	(1) Direct (immediate interpretation obvious to the senses).	(2) Indirect (requiring the interpretation of observed facts).	(3) Temporarily unrecognised (brought out by hypothesis and experiment).
A. Apparent (*i.e.*, more or less deceptive)	1–A	2–A	3–A
B. Occasional (dependent on a particular circumstance)..	1–B	2–B	3–B
C. Fundamental	1–C	2–C	3–C

In the Paper which follows this interdependence is studied in the particular case of light-alloy castings, although the problem is the same for all metals.

Influence on the Properties of Alloys of Indirect Factors during Melting

Experience shows that, in the best-managed foundries, the quality of the product is subject to inexplicable fluctuations which often disappear of their own accord. They are due to the intervention of indirect factors, the influence of which is small but cumulative, such as the increase in the amount of impurities in the metal by repeated remelting, and the consequent depreciation. The amount of such depreciation can be measured by the change in a given property, such as life, elastic limit, etc., or more simply by the increase in the number of rejects. It increases with the "net output ratio," M (*i.e.*, the ratio of the weight of metal charged in the furnace to the weight of good castings leaving the works). This differs from the "gross output ratio," m (the ratio of the weight of metal charged to the total weight of castings). Then if r is the proportion of scrap recharged at each melt,

$$\frac{1}{M} = \frac{1}{m}(1 - r) \quad .. \quad .. \quad (a)$$

At each charge the weight of good castings is replaced by an addition of new metal equal to $\frac{1}{M}$ and the depreciation takes place on the complement, A, of the preceding melt.

If α is the elementary coefficient of depreciation for each melt, the depreciation, T, after n melts is given by the following expression, which forms a convergent series:—

$$T_n = \frac{\alpha A\,[1 - A^n(1 - \alpha^n)]}{1 - A\,(1 - \alpha)} \quad .. \quad (b)$$

and, after an infinite number of remelts:—

$$T_\infty = \frac{\alpha A}{1 - A\,(1 - \alpha)}$$

or, in terms of M

$$T_\infty = \alpha\,(M - 1) + 1 \quad .. \quad .. \quad (c)$$

The depreciation is thus proportional, partly to the coefficient of depreciation, which depends mainly on direct factors (which are under control and should be favourable) and, partly, to M, which varies with the more or less insidious action of external factors, of which the influence is often unrecognised, and for which the *true* remedies often differ greatly from the *immediate* remedies.

Interdependence of General External Factors and the Properties of Alloys

Organisation of Production

If a factory be considered the current manufacture of which has a mean output of M_2, and it be supposed that important orders have to be met, for which the true output ratio, M_1 is greater than M_2 on account of foundry demands or increase in scrap percentage, a mean output ratio M' results, which is given by:—

$$M' = \lambda M_1 + (1 - \lambda)M_2 \,.. \quad .. \quad (d)$$

where λ is the percentage of the new manufacture, *e.g.*, a delicate type of aluminium aero-engine cylinder block involving a high scrap percentage ($M_1 = 4$) is introduced into a current production whose output ratio has been reduced to 1.5 (M_2). Then the mean output ratio is given by equation d as 2.75. This increase is clearly due to the mixing of the two manufactures, and it would be useless to apply direct remedies for the loss in efficiency of the original manufacture, which had not previously given trouble. The fundamental remedy lies in the reorganisation of the production on the following lines: The equilibrium of the two manufactures can be not only re-established, but even improved by casting "in echelon," *i.e.*, a certain number of melts are made for the current work, and the remainder for the new work, the scrap, however, being pooled. The new manufacture will have a virtual output ratio M_1', lower than M_1, the weight of castings produced at each melt remaining equal to $\frac{1}{M_1}$. The difference, therefore, must be absorbed by the remainder of the production, each melt of which will produce a weight of castings proportional to $\frac{1}{M_2}$ and equal to

$$\left(\frac{1}{M_1'} - \frac{1}{M_1}\right)\frac{1}{M_2}.$$

Hence

$$\lambda\left(\frac{1}{M_1'} - \frac{1}{M_1}\right)\frac{1}{M_2} \text{ must be equal to } \frac{1}{M_1}(1 - \lambda)$$

or

$$\frac{M_1}{M_1'} = 1 + M_2 \cdot \frac{1 - \lambda}{\lambda} \,.. \quad .. \quad (e)$$

The equation (e) gives a value of 1.60 for M_1' in the case of the examples chosen. It shows, too, that if the proportion of the new manufacture is not too great, or if its output ratio, M_1, does not exceed a certain value, the virtual output ratio can equal unity; that is to say, all the excess metal can be used up by the original manufacture without appreciable degradation.

Influence of Specialisation

Certain firms, for economic reasons, specialise in the quantity-production of a particular article. Such production is in a precarious state of stability. In the manufacture of automobile cylinder blocks the normal scrap percentage is about 12 per cent., but it periodically reaches 24 per cent., above which it is prohibitive. The reason is the depreciation of the metal with successive re-meltings by an amount which increases with the ever-increasing percentage of scrap reintroduced. The same thing is seen in aircraft work, and aluminium and magnesium castings generally, for which the output ratio is high and purity of the raw materials is important. Some firms wisely sell their scrap at low price to founders of less important castings; others shut their eyes to the problem, renewing stock and changing personnel when crises occur. It should be added that when the financial direction of a firm re-establishes its technical equilibrium by using new metal and putting excess scrap into stock, it can falsify completely the balance sheet of the firm by neglecting to allow for the depreciated quality of the scrap. Financial administrators are inclined to disclaim responsibility for the technical repercussions of their own directions.

Such are the dangers of specialisation, to avoid which it is necessary to supplement the principal manufacture of high output ratio by a secondary manufacture having a lower output ratio—for example, the casting of magnesium alloy wheels for aircraft ($M_1 = 4$) together with wheels for trucks in the same material ($M_2 = 1.5$).

Influence of External Specification

An increase in purity does not necessarily improve quality and may, indeed, reduce it, as was the case with Duralumin during the War, when restriction of the amount of scrap to be used caused a decline in the properties of the metal by reducing the excess of silicon necessary for the formation of Mg_2Si.

A tightening of the acceptance test on the finished product, by increasing the proportion of rejects, raises the factor M, and accelerates the depreciation T.

Effect of the Scrap Market

The development of aircraft work requiring a high proportion of virgin metal and having,

* A Paper read before the Paris Meeting of the Institute of Metals.

moreover, a high output ratio, the breaking up of old cars and aeroplanes, and many other sources, have created large floating stocks of scrap, the market value of which has decreased, owing to lack of demand. Later applications, such as the light alloy cylinder head, have given rise to competition, the principal cause of which is the use of such scrap by certain makers. The dangers involved need no emphasis; ten years ago the use of aluminium for cylinder heads was jeopardised by lack of consistent soundness. In the case of pistons, also, the much superior high-silicon alloys have been replaced to some extent by very cheap alloys, which owing to progress in design give a certain amount of satisfaction to the non-discriminating buyer. The existence of large floating stocks of scrap would thus appear to prejudice the development of serious applications unless research is carried out by producers to permit the use of secondary metal without bringing it into discredit.

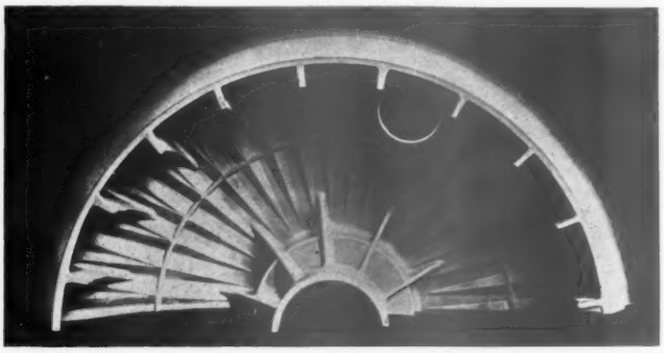

FIG. 1.—CAST AEROPLANE WHEEL. THE WEB IS COMPOSED OF PYRAMIDS ON A VERY THIN PLATE, TO ENSURE ADEQUATE FEEDING, AND CONTROL AND REDUCE INTERNAL STRESSES.

Foundry Factors

In the case of a pure metal or eutectic, the shrinkage is localised in internal cavities which do not usually communicate with the surface: with alloys having a solidification interval the phenomena are more complicated, and cause a succession of defects very different in appearance, but having the same cause. In both cases the problem of the foundry is to assure complete feeding of the still liquid portions of the casting from external sources. This is effected mainly by risers or denseners. The former are liable to reduce the cooling rate seriously, and to make higher casting temperatures necessary, thus reducing the mechanical properties of the alloy. Moreover, they obviously increase the output ratio, and, as a remedy for cavities, may have immediate success, whilst forming the root cause of troubles to come. It is always possible to replace a riser by a suitably placed runner, and it is equally possible to use chills, so reducing the output ratio, *M*.

Top pouring is to be recommended, since it eliminates at least one riser, but careful technique is required to avoid entrainment of oxide. It is difficult to distinguish between cavities due to gas and those due to shrinkage, since they can have the same appearance, and are subject to the same laws of progress, division, and localisation. In effect the imprisoned gas follows the free path of the remaining liquid metal, exactly as the shrink; they are both stopped in the same way and at the same points, when the metal becomes too viscous. Although the permeability of the sand affects the gas-hole and not the shrinkage cavity, yet the remedies for the latter are usually suitable for the former.

Iron crucibles are a possible cause of trouble in the foundry, as increase of iron content of the metal not only affects the mechanical properties but also increases the solidification interval. The physical and chemical quality of the moulding sand also introduces many indirect factors, and such unusual occurrences as the pick-up of soot from a neighbouring railway may lead to bad castings.

The question of design is perhaps best approached by imagining the casting to be divided into a large number of thermally differing zones, each of which is considered as a separate problem. A characteristic example is a magnesium alloy aircraft wheel, with heavy rim and thin web. If the latter is made of uniform thickness this cannot be less than 5 to 6 mm. on account of feeding and internal stress difficulties. It is, therefore, divided into a large number of radial pyramids (Fig. 1), giving a thickness, in the thinnest parts, of only 1.5 to 2 mm. and an average thickness of less than 4 mm. The thick parts feed the thin parts and split up the internal stresses. A similar construction is seen in the railway door of Fig. 2, the average thickness of the panel being less than 3.25 mm.

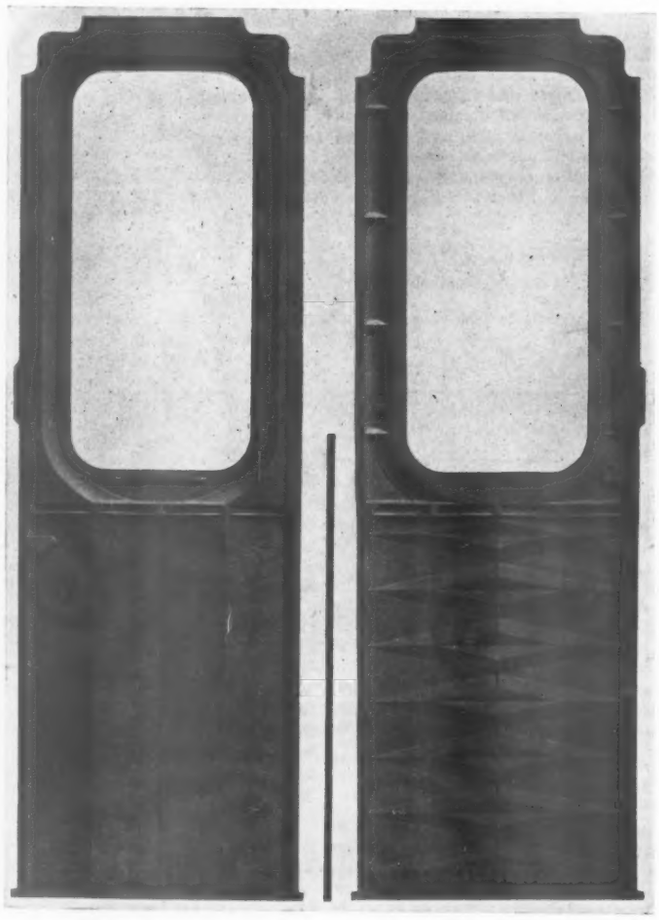

FIG. 2.—CAST RAILWAY DOOR. THE PANEL IS COMPOSED OF PYRAMIDS ON A VERY THIN PLATE, IN ORDER TO REDUCE FOUNDING DIFFICULTIES AND INCREASE RIGIDITY.

Relation of the Use of Alloys to their Properties

The Size-Factor

As has been seen, a feeding head, in suppressing shrinkage, may cause a cavity to appear elsewhere, and castings of more than a certain size, or difficulty, will suffer from a vicious circle of defects, the remedy for one (apparent, direct factor, 1-A) constituting an occasional, temporarily unrecognised factor, 3-B, in the appearance of another. If extreme measures have to be taken for a given casting, the factor of safety (in use) may be reduced by hidden defects. Safety in large castings is more likely to result from using alloys with a small solidification interval, which involves redesigning to allow for poorer mechanical properties, *e.g.*, the large monobloc castings in Alpax for marine work, which cannot be safely made in other alloys.

When Alpax was first used in France for cylinder blocks considerable difficulties with porous barrels were experienced, for which the quality of the metal was held responsible (apparent, direct factor, 1-A). The real cause of the trouble was the design (fundamental factor, 3-C), and German founders, using the same alloy, had no trouble, because they designed their blocks to take inserted barrels.

Large monobloc castings for severe duty cannot be made in high-strength alloys having a large solidification interval without prohibitive risks

(*Concluded on page* 224.)

Measuring and Controlling Pouring Temperatures and Fluidity*

By CARL F. JOSEPH

Technical control of all factors entering into the manufacture of castings has been the by-word of all progressive foundries during the past few years. Metal control, sand control, heat-treatment control and almost every other control have been practised, but in very few cases has temperature control entered into the picture. In the writer's estimation, one of the most important phases of foundry practice is the development and maintenance of uniform temperature control throughout all the operations.

The first step in developing temperature control is the choosing of the proper equipment to measure the temperature of the molten iron. There is considerable material in the literature covering the various methods to be used to measure temperatures of molten iron. The most satisfactory temperature measurements of molten iron have been made by using the disappearing filament type of optical pyrometer. The glowing wire of a small electric lamp is blended against the light emitted by the particular hot body as received through a telescope provided with lenses and colour screens suitable for the purpose. The lamp situated in the telescope is lighted and controlled from a portable case containing dry cells, variable rheostat and milliammeter. Comparison is made of the current flowing through the blended filament as measured in milliamperes with that shown on a calibration chart previously standardised by similar observations of hot bodies at known temperatures over a given range. It is more convenient to have the instrument calibrated to read directly in degrees temperature.

The furnaceman is only interested in obtaining comparable readings day after day and, while he is not interested in the question of absolute temperatures, for comparison sake over a period of time and also for comparison with the practice in other foundries, it is desirable to obtain the most accurate readings possible.

Since the optical pyrometers are used almost entirely by practical men, it is most important that they be kept in proper condition at all times. There is a general dissatisfaction with temperature observations and, in many cases, this has resulted in obtaining a wide range of readings, due to the fact that instruments have not been so kept. This may have been caused by dirty lenses, gradually deteriorating filaments, changing milliammeter characteristics, dry cells run down, not picking out the proper part of the stream in taking the readings, etc. Very often the inexperienced operator will sight on a slag streak which shows brighter in the field and thereby obtain a higher temperature reading. All these possible variations cause a difference in calibration and instil a lack of confidence in the operator, which, if allowed to occur, may ruin the value of temperature control in a plant.

At the plant with which the writer is connected, three optical pyrometers are available for use in service and one standard milliammeter is maintained in the laboratory, with two standard lamps. This standard equipment is never used in service. It is used only to check the service instruments periodically. The source of heat is the inside of a combustion chamber on a continuous annealing kiln, in which the temperature is very near that at which the optical is used in service and is maintained at a relatively constant temperature during the checking period. A correction for any discrepancy between the standard and service instruments is made when reading the service instrument. In this way, the service instruments always read correct temperatures.

Check with Standard Equipment

About once a year (oftener if found necessary) the standard equipment is checked against a standard platinum, platinum-rhodium thermocouple. The source of temperature is a Globar furnace with a refractory tube containing the platinum couple inserted. The optical pyrometer is focused on the inside and bottom of this tube at the hot junction of the thermocouple, giving a true black-body condition. This ensures a reliable check on the standard equipment. It has been found that in this way it is possible to maintain a standard within ± 5 deg. C.

Definite Plan of Temperature Control

Having established a means of accurately measuring temperatures of the molten iron, the next step is to have a definite control of the temperatures. In the plant where the author is employed, all of the iron is melted in the cupola, desulphurised in a forehearth and superheated in an electric furnace. The temperature of the cupola iron is read at intervals throughout the day. It is desirable from many angles to melt as hot as possible, as this practice gives less erosion of the cupola lining, better chemical control of the metal and less superheat in the electric furnace. The recarburising properties of the coke determine the amount that can be used and thereby regulates the temperature of the iron at the spout.

Iron from the cupola flows into a 10-ton bottom-pouring, electrically-tilted forehearth, where it is desulphurised and mixed. There is a loss in temperature at this point, since the iron is allowed to remain in the forehearth prior to being transferred to the electric furnaces for superheating. It is transferred to the electric furnace in a 3-ton insulated ladle.

It is an old custom in the majority of foundries to use pouring ladles constructed of a steel shell with an open top and lined with a satisfactory refractory. The radiation losses in such a ladle are very high and a wide variation in temperature is possible. It is necessary to superheat the iron very high and handle it rapidly to compensate for the drop in temperature while handling.

In the author's plant the amount of superheat formerly required was high due to the fact that in some instances as many as 20 moulds were poured from the same ladle of iron and very often it was necessary to pig the last iron. Personal practice at that time was to superheat the iron in the electric furnace to 1,590 deg. C. This meant that it was necessary to increase the temperature of the iron more than 195 deg. C. The iron was tapped at the cupolas around 1,480 deg. C., allowed to desulphurise in the forehearth, was transferred to the electric at about 1,395 deg. C. and superheated to 1,590 deg. C. The superheated iron was then tapped into 1½-ton open bull ladles and distributed to open-type pouring ladles of 500-lb. capacity. The last iron from these bull ladles would go into the pouring ladles at approximately 1,500 deg. C., and then drop to 1,393 deg. C. by the time the last iron was poured into the mould. Later in this Paper, fluidity tests will be shown where the pouring qualities of the iron drop off very rapidly when poured at temperatures less than 1,440 deg. C.

Development of New Ladle

To establish pouring temperature control, it was found necessary to reduce the high radiation losses occurring in the ladles used in transferring and pouring the iron. It is very expensive to superheat metal and, therefore, ways and means to conserve heat were studied. A new ladle, covered and insulated, was developed which greatly reduced the amount of superheat necessary in the electric furnace. This also allowed a 500-lb. ladle of iron to be poured within closer temperature limits.

A great deal of thought has been given to electrical heating equipment which would hold the pouring temperature in the ladle constant. Since experiments in this direction were unsuccessful, it was decided to use the insulated covered ladle. Some of the increase in good melt can be credited to the fact that it is now possible to control the pouring temperature within closer limits than by the old method.

Fig. 1 is a time-temperature curve showing the handling of the iron from the cupola to the mould. The old way was described above, and this has been changed as follows:—

Iron is tapped from the cupola about 1,535 deg. C. into a forehearth, transferred into a 3-ton covered ladle around 1,440 deg. C. and then into the electric furnace where it is superheated to 1,555 deg. C. The iron is distributed to the moulding conveyors by means of a 2,500-lb. transfer ladle and a 500-lb. pouring ladle. Both are insulated and covered. The temperature of the iron at the furnace spout is 1,555 deg. C. It drops to 1,520 deg. C. in the hot metal crane, and further to 1,475 deg. C. in the pouring ladle. The pouring range is usually maintained within 33 deg. C. so that the minimum temperature of the last iron from the pouring ladle is 1,385 deg. C. or more.

Iron is now tapped from the cupola at approximately 1,530 deg. C. into the forehearths, which have been completely covered except for a small 9 in. by 24 in. slot. The iron after being delivered to the electric furnace is superheated to approximately 1,555 deg. C. and tapped into the new type 1½-ton bull ladle.

Teapot Ladles

The general construction details of the new teapot pouring ladle are shown in Fig. 2, and consist of 2½ in. of refractory backed up with 1¼ in. of insulation and a ¼-in. metal shell. This shell is first lined with the insulating brick. A removable form is then inserted and the refractory wall rammed into place. The form is then removed and the refractory for the one closed end rammed in. The cover for the open end is then fastened on, and the insulating brick and refractory for this end is placed through the 8 in. by 8 in. opening and spout. The construction of the 1½-ton and 3-ton ladles is practically the same, except for an increase in thickness of the refractory wall, and the use of an additional removable form for ramming the top.

The average life of the new type pouring ladle is 42 actual pouring days as compared with a 4-day life of the old type. Although the relining cost of the new type pouring ladle is three times that of the old ladle, the actual cost per day of service for this new type ladle is much less than that of the old type ladle, due to its much longer life. The new type ladles require little patching except around the opening and at the spout. The covers for these bull ladles have an average life of four days. The temperature of the outside shell of the new type ladle is approximately 175 deg. C. as compared with an average temperature of 455 deg. C. on the old type ladle.

By comparison of the two curves in Fig. 1, it will be seen that a superheat of 105 deg. C. is now required as compared with 205 deg. C. superheat formerly necessary before the development of the new type ladle, and the change in cupola charge and operation. This change in the cupola charge consists of using a larger quantity of a different kind of coke and the substitution of some of the less expensive make-up charge for part of the pig-iron charge. The increased coke cost is entirely offset by the cost of the make-up charge.

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* A Paper presented to the Annual Meeting of the American Foundrymen's Association. The Author is metallurgist at Saginaw Malleable Iron Division, General Motors Corporation.

Results

Based on an average yearly production, the above methods of operation show the following results:—(1) A substantial reduction in the energy consumption required for superheating; (2) a substantial reduction in the electrode consumption; (3) increase in the capacity of the electric furnace; (4) reduction in the amount of foundry spillage; (5) increase in temperature of the last iron out of the pouring ladle by 40 deg. C.; (6) reduction in over-all ladle maintenance, and (7) improved working conditions for the foundry in general, and especially for the iron pourers and shifters due to cooler atmosphere and the ease of handling the new type ladles.

The new type ladle is responsible for a substantial saving of the first three items mentioned above, and practically all of the remaining items.

The preceding discussion on this practice of making and operating the insulated covered ladle is for the purpose of acquainting the foundryman with the pouring equipment necessary to obtain proper temperature control. Without this, or a similar ladle, pouring temperature control would be almost impossible. It is hoped that some day constant temperature control of iron in the pouring ladle will be realised. This, without doubt, will justify a considerable expenditure, taking into account the savings obtained in lower fuel costs, lower scrap, and higher casting yield.

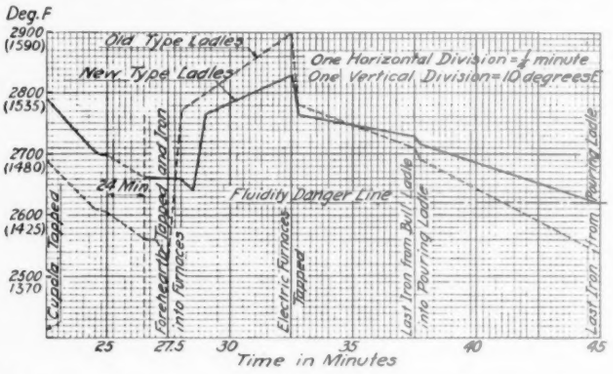

FIG. 1.—TIME-TEMPERATURE CURVE, SHOWING TEMPERATURES OF IRON FROM THE TIME OF TAPPING TO THE LAST IRON FROM THE POURING LADLE. THE PERIOD OF SUPERHEATING IN THE ELECTRIC FURNACE IS INCLUDED.

Furnace Control

Every furnace installation has its particular problem of temperature control. Many installations still use the old method of judging by eye, leaving the accuracy of operation almost entirely to guesswork. Indicating or recording instruments showing the fuel or power input are almost indispensable. The general opinion is that electric furnace melting and superheating are simple, when in reality they require more careful control to prevent overheating than most of the other forms of heating. In the author's case, supplementing the optical pyrometer reading, there is an instrument which shows the total kilowatt-hours input for each ladle of cupola metal added. A given predetermined number of kilowatt-hours are given to each ladle and the temperature checked with the optical pyrometer.

Measuring Temperature of Molten Iron

Some plants use a fluidity test to control the temperature at which the iron is tapped, while the most common still used in many plants is the spoon test, consisting of dipping the spoon into the furnace, withdrawing the iron and keeping track of the length of time the metal surface remains free from oxide formation or completely covers it.

The fluidity for control of correct tapping temperature in some plants is a stepbar ranging in sections from 1 in. down to $\frac{1}{16}$ in. In other cases, notched spirals of a standard length must be obtained prior to tapping the heat. In a large continuous casting foundry, spiral test moulds are poured every 15 minutes throughout the day. The length of the spiral must fall within predetermined limits. From the standpoint of mould running ability, the fluidity tests mentioned are better than the stop-watch test.

A method of measuring molten iron which uses a graphite-silicon carbide thermocouple is about to be marketed, which is claimed to indicate accurate temperatures over a period of time. This will serve a much needed want in the field of ferrous melting.

Many plants use some means of storing a large volume of iron just prior to pouring. This has a two-fold purpose—to make for uniformity of analysis and to maintain a more constant pouring temperature.

Fluidity *v.* Temperature

It is a fact that certain melting processes produce a more fluid iron at lower temperatures. How much difference there is in the degree of fluidity between electric, open-hearth, air or rotary pulverised-fuel furnace, producing the same analysis iron, is difficult to state. Perhaps the furnace atmosphere, as will be discussed later, is the most important factor. Various fuels used in melting have been mentioned as influencing fluidity. The point is, it is evident that the fluidity of iron is not altogether a function of temperature and that there are many variables affecting fluidity. Of the two, fluidity is more important than temperature, since it is of primary importance to fill the mould completely. Also, the greater the fluidity the more easily the casting will feed and the greater the casting yield.

Study of Fluidity

Foundrymen are interested in the fluidity of iron because it affects their costs. They look upon fluidity as the property of the molten iron to fill a sand mould completely. Unfortunately, many cases exist where other factors besides the iron or the temperature cause the metal not to fill the mould, which at times is blamed on the metal. Only by a thorough analysis of the many factors involved can the cause be determined.

The following are some of the foundry factors which influence the fluidity of the metal, and are often the cause of the poor running quality of the iron:—

Core	Hard cores which will not allow gas to escape.
	Dense cores which will not allow gas to escape.
	Shift of core in mould.
	Worn-out corebox.
Pouring	Haphazard pouring.
	Speed of pouring.
Sand	Coal dust content of moulding sand.
	Moisture content of moulding sand.
	Permeability of the moulding sand.
Pattern	Design of casting.
	Design of gating.

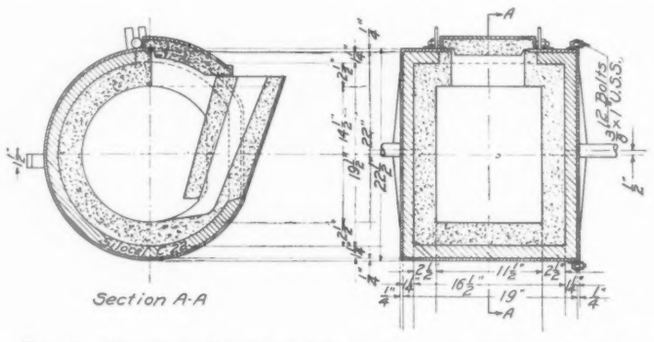

FIG. 2.—SECTIONAL VIEWS OF 500-LB. INSULATED POURING LADLES.

The usual metal thickness of the malleable iron castings is $\frac{3}{16}$ in. or over, which iron is poured at the standard temperature. If it should become necessary to pour castings less than $\frac{3}{16}$ in. thick, the pouring temperature must be increased. One important factor in pouring cored light sections is to have a soft permeable core, otherwise, cold shuts and misruns will occur.

Size of Casting

When the casting surface is large in relation to the mass, the sections are usually light, and consequently, it is necessary, as a general rule, to increase the pouring temperature of the casting to avoid misruns. Hotter iron must be poured into such castings than that used in the more lumpy castings. In other words, the temperature of the iron in either case must be high enough to fill the mould completely.

On the other hand, the temperature must not be too high. Fuel costs, especially when electric heat is used, rise rapidly as the superheating temperature is raised, due principally to radiation loss. When iron was tapped at 1,590 deg. C., the k.w.h. consumption was approximately 25 per cent. higher than when the same iron was tapped at 1,555 deg. C. Refractory and furnace maintenance costs also were considerably higher.

The pouring temperature has a marked effect on the amount of clay for rebond necessary to maintain the proper bond strength. Also, increasing pouring temperature increases the sand losses from the moulding system due to the fact that more sand adheres to the castings. In this manner, the maintaining of a constant pouring temperature facilitates the control of the moulding sand.

In air furnace practice, very often at the start of the heat, heavy castings, which do not misrun easily, are poured first. Later, as the iron becomes hotter the lighter castings, which are more apt to misrun, are poured. In conveyor moulding, where iron is pouring continuously throughout the day, the iron must be tapped at the same temperature at all times to obtain uniform results. Moulding conveyors at close proximity to the melting department should take care of the lighter castings, and those conveyors furthest away, the heavier castings.

Pouring temperature will depend largely upon the kind of metal poured. For any two irons poured at the same temperature, the running qualities are better in the case of the iron having the lower liquidus temperature.

Pouring Time

A short pouring time on a casting with large wide gates may mean lower iron pouring temperatures completely to fill the mould than a long pouring time resulting in passing the same amount of metal through restricted narrow gates. Therefore, the length of pouring time must be adjusted on certain castings to conform to the pouring temperature adopted as standard.

The author has tried to establish a formula for determining the duration of pouring or size of gates for certain classes of castings, but

while the information may be useful, it is apt to lead to trouble and the most reliable method is to gate from past experience.

Metallurgical Factors Influencing Fluidity

Metallurgical factors influencing the fluidity of iron may be listed as:—Carbon content of metal; silicon content of metal; phosphorus content of metal; nature of raw material in the charge; desulphurising with soda ash; and atmosphere.

The conclusions drawn from the above metallurgical factors as they influence fluidity are from practical observations over a period of many years on white iron made in air furnaces using hand-fired coal, powdered coal or oil as fuel, and also metal melted by the cupola-electric process, to be later malleablised. No definite ranges will be given as to the point to which elements must drop before fluidity is affected, but in general, carbon, silicon and phosphorus have an adverse effect on fluidity as they are lowered. The decrease in fluidity is more marked with the lowering of carbon than silicon or phosphorus in the usual run of iron melted. Manganese does not affect the fluidity within the usual limits.

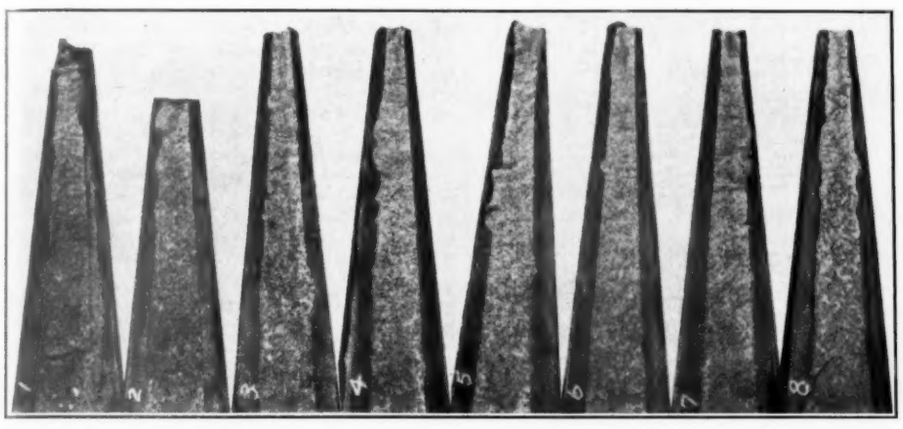

Fig. 3.—Test Wedges, showing Effects of Pouring at Different Temperatures.

The higher the steel content of a charge, the hotter the metal must be heated to obtain the same fluidity, therefore, it can be concluded that increase in steel content of a charge lowers fluidity. This decrease in fluidity has been noted even though the carbon content remains the same.

Desulphurising with soda ash deoxidises the metal. It removes the non-metallic materials and this purification of the metals is characterised by an increase of fluidity.

Atmosphere Affecting Fluidity

The atmosphere in which the metal is heated has an influence on the fluidity of the metal. It has been noted that when the electric furnace is sealed tightly and there is an absence of a flame around the electrode cooling glands, the iron (even though at the proper pouring temperature) does not handle well. The exclusion of air causes a more reducing atmosphere in the furnace which results in this lack of fluidity.

This lack of fluidity in metal due to reducing atmosphere is also found in steel melting practice, where steel lacking fluidity is changed to a very fluid state by the addition of a small amount of iron ore. In other words, over-reduced metal is less fluid, and can be quickly changed to a more fluid state by oxidation.

In air-furnace practice, the amount of oxidation of carbon, silicon and manganese from the original charge to the final iron poured, affects the fluidity. The less the oxidation loss of the elements the better the iron handles in the ladle at the same temperature with the same chemical analysis. Therefore, it is concluded that fluidity is adversely affected by increase in oxidation of the elements. This must not be confused with the over-reduced atmosphere over a molten bath, which also adversely affects fluidity.

Mottling of Iron Due to Temperature

The effect of pouring temperature on the mottling tendency of white iron must be viewed from two angles. First, iron which is heated from a lower to a higher temperature; secondly, iron which is cooled from a higher to a lower temperature. In the first case, the cold iron will mottle more easily, and as the temperature is raised, without change in chemical composition the mottling will become less. In the second case, the hot iron heated to, say, 1,590 deg. C. and cooled to 1,425 deg. C. does not change much in mottling tendency. These tests were made by pouring a round test sprue 7 in. long with one end 1½ in. in diameter, the other 1⅜ in. This test specimen is used at the author's plant for mottle control.

A more sensitive test for determination of the mottling tendency *v.* cross section area as affected by temperature is shown in Fig. 3. These wedges are 12 in. long, 1 in. square at one end, and 3¼ in. at the large end. A ⅝ in. slot to facilitate breaking is cast the entire length of the wedge.

Fig. 3 shows eight wedges. Those marked 1 to 4 inclusive were poured from the same iron heated from 1,425 to 1,590 deg. C. No. 1 was poured at 1,425, No. 2 at 1,480, No. 3 at 1,535, and No. 4 at 1,590 deg. C. It is noted that No. 1 shows the most mottle. No. 2 less and Nos. 3 and 4 about the same.

Wedges marked 5 to 8 inclusive were poured from the same iron as wedges Nos. 1 to 4, after being held hot in the furnace for 5 min. No. 5 was poured at 1,590, No. 6 at 1,535, No. 7 at 1,480, and No. 8 at 1,425 deg. C., all from the same ladle of iron. It will be noted that No. 5 shows the least mottle, Nos. 6 and 7 about the same, and No. 8 increasing slightly in mottling tendency. These tests were repeated a number of times with the same results as shown.

It has been noted that certain castings with a very thin wall next to a core will show mottled areas in the light wall section and perfectly white in the heavy section when poured at a temperature over 1,565 deg. C. This suggests the possibility that carbon may be thrown out of solution when iron is heated too hot and cooled too rapidly in the light sections. Another theory for these mottled areas is that the hot iron running over the sand heats the mould and allows the iron to cool more slowly. The same iron poured into the same casting at a lower temperature does not show the mottled areas in the light sections.

Effect of Tensile Strength and Hot Cracks

A study of the effect of pouring temperature on tensile properties was made covering a period of many weeks. Tensile bars were poured at 1,425 to 1,590 deg. C. from specially melted iron and from production iron. No definite conclusion could be drawn as to whether hot or cold poured bars showed any better physical properties. Some tests showed slightly higher strength when poured hot and the next run higher when poured cold. Generally, however, it is preferable to pour test-bars on the hot side, as they give a cleaner bar.

There was the same experience when trying to determine the effect of hot and cold iron on hot cracks. Some tests showed hot iron to cause more cracks and again cold iron showed more hot cracks. The tests were run on a production job which was prone to hot cracks. If anything, the cold iron had a tendency to show less hot cracks, although the difference was so slight no preference could be made.

It is quite possible that fluidity is the controlling factor in the cracking tendency of lower carbon iron. In the production of white iron castings for malleablising, every foundryman knows that the carbon content of his metal must be held above a given minimum, otherwise hot cracks occur. This same condition exists in steel casting practice where high carbon steels remain fluid in the mould for a longer time and pieces cast from these steels are less liable to crack than lower carbon steels. While fluidity may be responsible for non-cracking, it surely has no bearing on the cracking that takes place after the casting has completely solidified, but still at a high temperature, unless the internal strain in a casting increases with less fluid iron.

In general, hotter iron is preferred by the foundryman, and less scrap is poured when iron is on the hot side. Better still, temperature control will ensure the same temperature iron every day and hold scrap losses, due to temperature, to a minimum. Cold shuts, misruns, and shrinks very often are the result of too low pouring temperature which can easily be avoided.

(To be concluded.)

A New Steel Alloy for Pistons

A cast piston which is considered to be superior to aluminium-alloy and cast-iron pistons for automobile engines has been developed by the Ford Motor Company. According to E. F. Cone, in "Metals and Alloys," the alloy contains the following elements in addition to iron, C 1.35 to 1.7, Mn 0.6 to 1.0, Si 0.9 to 1.3, S. 0.08 max., P 0.1 max., Cu 2.5 to 3.0, and Cr 0.15 to 0.2 per cent., and may be described as a high carbon-copper-silicon steel. It casts and machines well, has mechanical properties that enable a thin-walled piston to be used, a high resistance to wear and a suitable coefficient of expansion. It thus in some measures combines the advantages of aluminium and cast-iron pistons. After casting in green-sand moulds, the pistons have a structure consisting of pearlite and cementite. They are heated to 900 deg. C. for 20 minutes, air cooled to 650 deg. C., heated to 760 deg. C. for one hour, cooled to 540 deg. C., and kept there for one hour before being finally cooled. This sequence of treatment is carried out in gas-fired, roller rail-type continuous furnaces, and the resulting structure consists of rosettes of temper carbon in a matrix of spherodised pearlite. After heat-treatment the mechanical properties are: elastic limit, 31 tons per sq in.; tensile strength, 40 tons per sq. in.; elongation on 2 in., 5 per cent., and Brinell hardness, 207 to 241. Machining is performed on a Bullard multimatic machine and the outside diameter is held to a limit of 0.0003 in.

The second blast furnace of the Novo-Tula Metallurgical Combine (Moscow Province), and the 119th in the Soviet Union, was blown in a few days ago. The blast furnace has a capacity of 800 tons of pig-iron per day.

Castings in Silumin Gamma*

By G. SACHS and E. SCHEUER

Aluminium alloys capable of age-hardening by the precipitation of Mg_2Si from solution have been in use for some time as the forged alloys Pantal, Anticorrodal, Polital, etc. It was shown by Hanson and Gayler[1] that an increase in the silicon content did not impair the ageing properties of the alloys, but that magnesium in excess of the proportion necessary to form Mg_2Si had a prejudicial effect. Alloys with a high silicon content are now used almost exclusively for casting purposes, and although the age hardening of such material has only comparatively lately been studied, the application of heat treatment to castings in light alloys with the object of improving the mechanical properties has already made considerable headway.[2 3 4 5] The reason for the comparative neglect of the aluminium-silicon alloys was that, in the usual sizes of test bar, ranging from 0.5 to 1.0 in. in diameter, these alloys were inferior to aluminium-copper alloys and also those containing magnesium, copper and nickel, with an aluminium base. In larger castings, however, the positions were reversed. As soon as the excellent casting properties of the eutectic aluminium alloys were made known the Al-Si-Mg alloy, known in Germany as Silumin Gamma, and in other countries by various other names, was introduced, and since then its valuable characteristics have been amply demonstrated. By the use of this alloy, large and complicated castings, free from defects, and with good mechanical properties, can be produced with the greatest regularity. The approximate analysis of the alloys of the Silumin Gamma type is, Si 12 per cent., Mg 0.4 per cent., Mn 0.5 per cent., remainder Al, but the silicon and magnesium may both be varied within certain limits.

Second only to the excellent casting properties of such alloys is the ease with which they can be heat treated. Heavy castings such as automobile Diesel engine housings weighing up to 900 lbs. can be quenched in cold water with perfect safety, in spite of the presence of sharp corners and large changes of section on the castings. Many other alloys with good intrinsic properties are prone to fail by intercrystalline cracking when subjected to rapid quenching and cannot be used for large castings that must afterwards be heat treated. Intercrystalline cracking is a serious defect, particularly when alternating stresses have to be withstood in service.

The equipment necessary for the quenching of Silumin-γ is very simple. The casting is generally placed in an iron basket and held in position by loose clamps. In the case of thin-walled or light, intricate pieces, a simple form of supporting framework may be used to avoid distortion of the casting by its own weight. The basket, supports, and the clamps must be kept as open as possible so as not to impede the free access of the quenching medium to all parts of the casting. Slight warping or distortion frequently occurs as a result of quenching, but straightening is easily carried out if done immediately after the treatment. In the aged condition the alloy is too hard to permit of any appreciable cold straightening being done. Age-hardened Silumin castings should be treated like cast iron, that is, deformation should be avoided. Thus, in the mounting of Silumin castings care should be taken that fixing bolts do not have to be forced through holes that are slightly undersized, as is sometimes done with aluminium castings, or cracking may result.

Internal Stress

A general objection to quenching operations on large sections might be raised on the grounds of the development of internal stresses. It may be said here that no difficulties arising from this source have been encountered in practice, and the objection cannot be sustained on theoretical grounds, as it has been shown that quenching stresses appear to a much smaller extent in alloys of the Silumin type than in other materials.[6] In addition, it has been demonstrated that such stresses as are created are so disposed as to bring about a compressive stress in the surface layers of the casting, and this is an advantage as regards the mechanical stability of the metal. Quenching with the deliberate intention of producing a certain distribution of internal stress with a view to improving the properties of the metal for some service conditions has even been proposed for steel.[7]

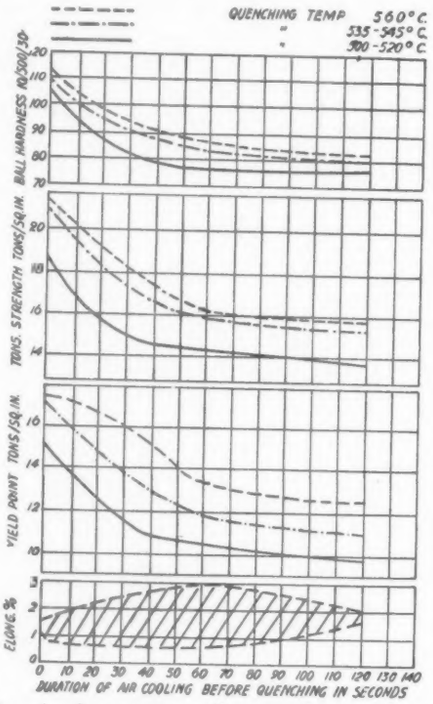
QUENCHING TEMP 560°C
" 535-545°C
" 500-520°C
BALL HARDNESS 10/500/30
TONS STRENGTH TONS/SQ.IN.
YIELD POINT TONS/SQ.IN.
ELONG. %
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
DURATION OF AIR COOLING BEFORE QUENCHING IN SECONDS

FIG. 1.—INFLUENCE OF DELAYED QUENCHING ON MECHANICAL PROPERTIES AFTER AGEING.

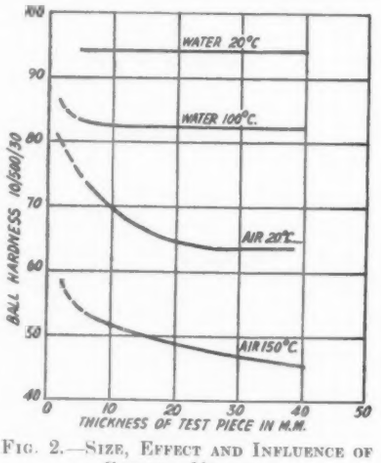

FIG. 2.—SIZE, EFFECT AND INFLUENCE OF COOLING MEDIUM.

If, after quenching a Silumin casting, an appreciable amount of metal has to be removed by machining, distortion may occur owing to the partial relief of the stresses in the reduced sections, and in cases, where, for any reason, large machining allowances have to be provided on the casting, these should be removed as far as possible before heat treatment is performed.

The transference of heat treatment processes for Silumin from the laboratory to the foundry has necessitated a great deal of further work on the practical aspects of the problem, in order to ensure with certainty the attainment of satisfactory and uniform properties in the treated castings. The results of these studies, in so far as they are of direct practical importance, will now be dealt with in some detail.

The difficulty of predicting the properties of large masses of metal from the results of small-scale investigations is especially marked in the case of castings. In general, it may be said that the properties of the small bars and plates cast for laboratory testing are superior to those obtained in industrial castings. This size effect is sometimes used to account for the rejection of castings with unexpectedly poor properties, and variations in moulding and casting technique are often employed only to correct superficial or internal casting defects, instead of being used to compensate, as far as possible, for the disadvantages inherent in the casting of large sections. In the case of Silumin-γ, careful work has shown that attention to these factors, particularly in relation to the subsequent heat treatment, can bring about a marked improvement in the properties of the castings. In some of the earliest castings in Silumin-γ very low hardness results were obtained on some sections. An investigation of this fact succeeded in demonstrating more than one factor capable of producing the observed effect, and as a result of this work a number of important practical recommendations could be made.

Quenching

In the exhaustive examination of an aero engine casting it was found that only the heaviest sections gave the anticipated hardness of more than 90 (B.H. 10/500/30.). In thinner sections the hardness fell as low as 70, and the tensile strength and yield point showed a similar dependence on the thickness of the cast section. These results were contrary to the usual experience with castings where the heaviest sections are weakest. A study of the results obtained with Silumin led to the conjecture, later verified, that the variation in properties was caused by the thinner portions of the casting cooling below the optimium quenching temperature during transference from the soaking furnace to the quenching bath. The curves shown in Fig. 1 illustrate the effect of delayed quenching on sections measuring 5 by 20 by 100 mm. The graphs show clearly that the best properties in the aged alloy are obtained only when the period of transference from heating furnace to quenching bath lasts no more than 10 seconds. With a 30-second interval, the hardness of the treated alloy is 20 per cent. below that of the best attainable, and the tensile strength is 15 per cent. lower.

The use of higher soaking temperatures, as the curves show, compensates in some measure for the unfavourable effect of delayed quenching. In the foundry the speeding up of the quenching process was achieved by the use of a jib crane fitted with an electric power block to lift the castings out of the heating furnace and lower them into the quenching bath. By this means the time necessary for the quenching of the largest casting was reduced to 5 to 10 seconds. Castings treated in this manner had much better mechanical properties than was formerly the case, and were, in addition, much more uniform in structure and hardness. In much the same way the use of an inefficient quenching medium reduces the hardness obtainable in treated castings, as is illustrated in Fig. 2. With Silumin-γ it is essential to use cold water

* Abridged translation from "Metallwirtschaft."

only as a quenching medium if the best properties are to be obtained by the treatment.

In comparison, the influence of the above factors on the properties of forged Al-Cu alloys seems to be much less. Tests carried out on Duralumin and Lautal have shown that quenching may be considerably delayed without much prejudice to the final properties of the alloys.[8] With plates of a size similar to those used for

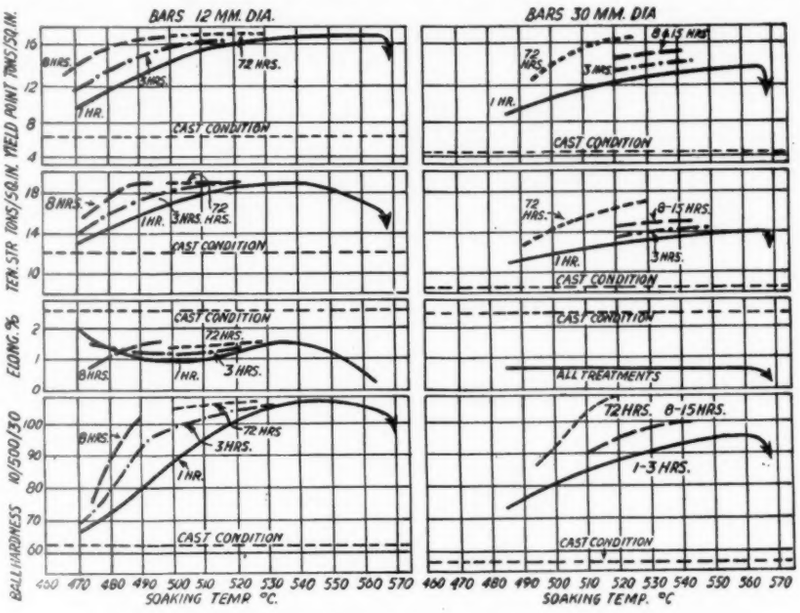

FIG. 3.—INFLUENCE OF TEMPERATURE AND DURATION OF SOAKING.

Silumin, air cooling from the soaking temperature gave a tensile strength in the aged alloy only 6 per cent. below that obtained after quenching in cold water.

Casting and Solution Treatment

Fig. 3 shows curves illustrating the influence of soaking time and temperature on the final properties of Silumin-γ. The most evident conclusion from these curves is the extreme importance of a high soaking and quenching temperature. The practicable maximum is about 540 deg. C., because at approximately 550 deg. C. the ternary eutectic Al-Si-Mg_2Si begins to melt, and the alloy becomes "burnt," a condition that must be avoided at all costs.[1] To be on the safe side, the normal treatment for Silumin-γ is a three-hour soak at 525 ± 5 deg. C., and it is important to see that the temperature is as high as is permissible just before quenching is performed. In mild cases of overheating the surface of the metal shows small dark grey patches (magnesium nitride?). In more severe cases the alloy seems to sweat small globules of metal. These globules consist of the ternary eutectic mentioned above, and in a casting showing this defect, the microstructure shows pores caused by the partial extrusion of the molten eutectic. Any molten eutectic present in the alloy when quenched can readily be identified under the microscope because of its extremely fine structure.

The examination of a large number of castings showed that, in the case of some thick-walled and complex shapes, very low hardness results were obtained, even when the precautions already described were carefully observed. In these cases the low hardness was due primarily to the slow solidification of the castings, which were made in warm, dry, sand moulds. As Fig. 3 shows, thin castings can be efficiently hardened after a soaking treatment of only 1 hour, but heavier sections may require up to 8 hours' treatment to produce similar results. The reason for this is to be sought in the state of subdivision of the magnesium silicide in the microstructure of the castings.

The silicide exists as extremely fine dendrites, which can only be distinguished from the Al-Si eutectic at fairly high magnifications. An examination of microsections from sand castings of various dimensions, and therefore with different rates of solidification, gave the following rough indication of the relationship between wall thickness and the condition of the silicide. For castings 10 mm. in thickness, the average distance between dendrites was 0.5 mm., and the cross-section of individual dendrites was 0.05 $mm.^2$ For castings 50 mm. in thickness the separation was 1.5 mm. and the cross-section 0.10 $mm.^2$, and for castings of 100 mm. the figures were 5 mm. and 0.30 $mm.^2$ respectively.

For satisfactory age hardening, the soaking treatment must bring about a complete diffusion of the hardening component, in this case the silicide, throughout the alloy, and for this reason the treatment is sometimes referred to as homogenising. Such homogeneity is readily attained in thin sections owing to the original fine state of dispersion of the silicide, but to bring about a uniform solution in the two latter examples quoted an impracticably long soaking treatment would be necessary. The speed of diffusion of the silicide and the concentration gradient (less than 1.8 per cent. Mg_2Si for 2.5 mm.) are both too low to permit of a speedy redistribution.

In this connection it may be mentioned that the usual experimental procedure of examining the same section microscopically before and after heat treatment cannot be applied to Silumin, since even *in vacuo* long treatments tend to obscure the Mg_2Si crystallites by some etching or oxidation process. The difficulty of performing an efficient homogenising treatment on thick castings may be surmounted by a variation of the casting technique whereby the heavy sections are more rapidly cooled by suitable chills inserted in appropriate positions in the sand moulds. Such measures, in the case of some alloys with poor casting properties, are fraught with considerable difficulty and demand great experience on the part of the moulder, but with Silumin chills may be employed in great variety with the most beneficial results.

Finally, where some foundries have only begun to undertake the production of castings in Silumin-γ, cases have occurred where castings have given poor hardness results even after the most careful heat treatment. The only likely explanation was that the magnesium content of the alloy was too low. Unfortunately, the estimation of magnesium in small quantities in Silumin is not very accurate, but, in general, a deficiency in the element has been demonstrated in such cases (0.1 to 0.25 per cent. instead of 0.3 per cent. Mg, as required for the specified composition). It was thus made evident that magnesium could be volatilised or oxidised out of the molten alloy, but the actual conditions governing the phenomenon could not be accurately determined. In normal practice the loss of magnesium in melting ingots of Silumin-γ is very small.

Certainly the use of sodium and other salts to form a protective cover for the melted alloy can lead to loss of magnesium, and a deficiency may also be found after the remelting of light scrap which suffers more severe oxidation during fusion. Salt covers should be avoided when melting Silumin or permitted only when their action has been carefully studied and the necessary precautions taken to prevent the magnesium content from falling below the prescribed level. When scrap is being remelted, a small addition of magnesium may be made to compensate for any loss, but in no case should the addition necessary exceed about 0.05 per cent. of the weight of the scrap charged.

Mechanical Properties

In the production of age-hardened castings, the ageing process itself is probably the least critical of the various stages involved. Fig. 4 shows that full age-hardening may be obtained after a 20-hour treatment at 150 deg. C. or a 4-hour treatment at 180 deg. C. Care must be taken, however, that the chosen temperature is not exceeded during the treatment or the duration of the heating prolonged beyond that necessary to realise the best properties, otherwise poor results will be obtained. The variation in mechanical properties that can be obtained by suitable heat treatment is shown in Fig. 5. Especially noteworthy is the high fatigue

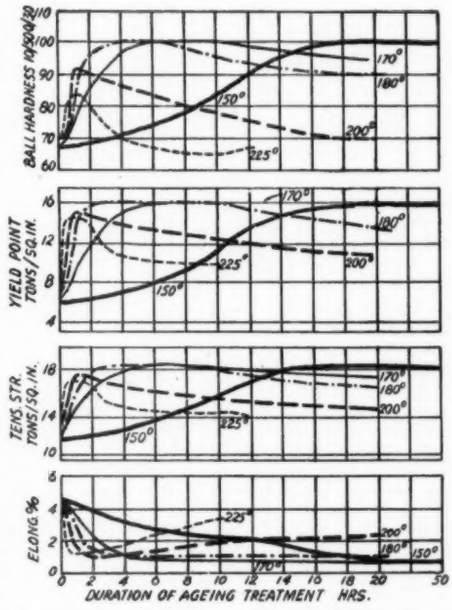

FIG. 4.—INFLUENCE OF AGEING TEMPERATURE.

strength of the alloy in the quenched state, although the yield point and hardness are both low.

The fatigue strength is not affected by subsequent ageing, but the other strength properties are considerably improved. If the homogenising treatment be ineffective, or nullified by slow cooling (air-cooled condition) or tempering between 250 and 350 deg. C. (soft annealed condition), the tensile strength, hardness, and fatigue

strength are all unfavourably affected, and may fall below the values obtained in the cast alloy. It is interesting to note that the fatigue strength of Silumin-γ is not affected by the superimposition of aqueous corrosion, although for many other metals, including Electron and cast iron, corrosion fatigue has a very grave effect, particularly at high endurances.

The properties obtainable in cast test bars 12 mm. in diameter are not generally realised in sand castings, but in simple patterns that can be satisfactorily provided with chill plates in the moulds, the properties of the test bars can frequently be improved upon. For example, the first casting of a small Diesel aero engine housing with wall thickness varying from 4 to 12 mm. gave, from 23 test pieces, tensile strengths varying from 11.1 to 20.9 tons per sq. in. with an average of 17.3 tons per sq. in. The mean yield point was 15.3 tons per sq. in, with extreme values of 14.0 and 16.9 tons per sq. in., and the elongation varied between 0.3 and 2.0 per cent. with an average of 0.9 per cent. The hardness results were more uniform, ranging from 84 to 109 with a mean of 99.

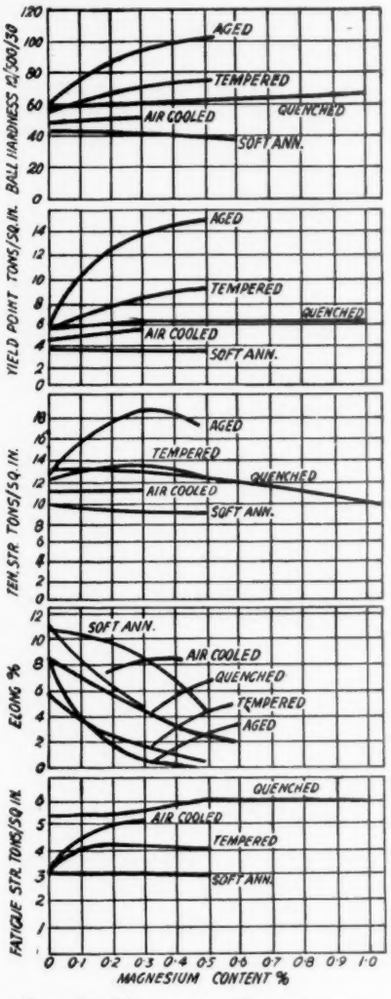

FIG. 5.—MECHANICAL PROPERTIES OF SILUMIN GAMMA CASTINGS AFTER VARIOUS HEAT TREATMENTS.

(Tempered 150 deg. C. 20 hrs. Air-cooled 510 deg. C.-529 deg. C. 3 hrs. Quenched 510 deg. C.-520 deg. C. 3 hrs. Soft annealed—aged, then 350 deg. C. 8 days).

Values of tensile strength below 16.6 tons per sq. in. were obtained only on test pieces taken from some parts of the casting where the feeding arrangements had been inefficient and the metal was not sound. In another motor housing, taken this time from current production, the tests gave a mean tensile strength of 20.0 tons per sq. in. (17.9 to 22.1) with a mean elongation of 2.0 per cent. (0.8 to 3.8 per cent.) and a ball hardness of 109 (98 to 116). In this case the size and shape of the housing was such that casting could be performed under the most favourable conditions, and to this must be attributed the excellent results obtained.

A survey of test pieces cut from 11 different castings, varying in weight from 29 to 660 lbs., gave the results shown in Fig. 6. Some of the results were obtained on the first castings of a new series of products, and it must be observed that in repetition work considerably better results could be achieved by careful supervision. The broken line curves refer to the second engine housing mentioned above, and indicate what good properties may be obtained where the most effective technique can be and is employed.

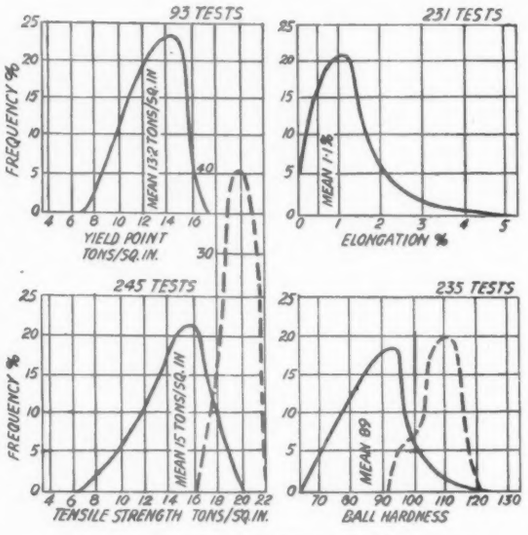

FIG. 6.—STATISTICAL RESULTS OF MECHANICAL TESTS ON 11 CASTINGS, VARYING IN WEIGHT FROM 29 TO 660 LBS.

The determination of the fatigue strength of bars cut from some of the above castings gave more regular results than the tensile tests, and it was observed that low results were associated with porosity in the test pieces. The strengths obtained, on a basis of 20 by 10^6 stress reversals, varied from 3.6 to 5.4 tons per sq. in. with a mean value of 4.5 tons per sq. in. It may be said that the lowest of these figures represents the fatigue strength of castings produced under unfavourable conditions, and where proper provision can be made for chilling the moulds higher values are likely to be obtained.

TABLE I.

Casting.	Weight, lbs.		Yield point.*	Tensile strength.*	Elongation per cent.	Hardness.
Fuel pump	5.5	Lowest ..	18.4	20.0	1.0	97
Thickness, 8-13 mm. ..	—	Highest ..	19.4	22.2	2.2	120
27 test pieces	—	Mean ..	18.5	21.0	1.6	107
Cylinder block	22.0	Lowest ..	—	(10.0)†	(0.4)†	88
Thickness, 4-10 mm. ..	—	Highest ..	—	20.0	2.2	110
22 test pieces	—	Mean ..	—	16.1	1.1	98

* Tons per sq. in. † Test piece with inclusions.

Very good properties can be obtained from chill castings, which may frequently be used for large outputs of repetition work. In Table I are gathered the results obtained on chill castings of a simple little fuel pump and a very complicated large-cylinder block.

The first gave the very high average tensile strength of 21.0 tons per sq. in., and the latter the somewhat lower figure of 16.1 tons per sq. in., but it is to be noted that the cylinder block, on account of its shape, could not be cast entirely in a metal mould, and some sand cores were used, so that some non-metallic inclusions from this source were almost inevitable. In the determination of the mean mechanical properties of the large casting, the results obtained from test pieces containing obvious inclusions were not excluded.

Fatigue tests on bars taken from the cylinder block gave results varying between 5.1 and 6.4 tons per sq. in. That these results are about 20 per cent. lower than those obtained on specially cast bars is almost certainly due to the presence of inclusions. In one case it was observed that an inclusion occupied about 20 per cent. of the fractured face of the test piece, so it would appear that the sensitivity of the alloy to such defects is not marked. In comparison it may be noted that castings in ordinary Silumin from the same moulds gave fatigue strengths of less than 3.8 tons per sq. in. on test pieces free from defects.

Up to the present, experience of the practical uses of Silumin-γ is limited to conditions involving temperatures not higher than 150 to 170 deg. C., and it cannot be said how far the properties of the alloy would be maintained at temperatures higher than these, but researches are in progress to elucidate these matters. At the moment, Silumin-γ cannot be recommended for castings which must possess high strength at elevated temperatures, but several special alloys, based on Silumin-γ are being developed for such applications.

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5 Kennedy, Amer. Foundrymen's Assn. (1934). Preprint No. 34-1.
6 Kempf, Hopkins and Ivaso, Amer. Inst. Min. Met. Eng., Techn. Publ. (1934), No. 535.
7 Greene, Trans. Amer. Soc. Steel Treaters, 18 (1930), pp. 369-403.
8 Zeerleder, J. Inst. Met., 46 (1931), pp. 169-180.

Catalogue Received

Molybdenum in Grey Iron. The Climax Molybdenum Company, of 500, Fifth Avenue, New York City, in a six-page, well illustrated brochure, describe tests which were made to elucidate the effect of molybdenum on various types of cast iron. Seven samples were used for comparison with a plain grey iron, in which the molybdenum rose from zero to 1.02 per cent., and with it the tensile strength increased from 15.6 tons to 24 tons per sq. in., associated with a 207 to 241 increment in Brinell hardness. The next series related to a 0.57 per cent. chromium iron, with a molybdenum range of zero to 0.53 per cent. At the end of this series a 25-ton tensile was achieved with roughly half as much molybdenum. The Brinell hardness was returned at 255. The final series, also of seven samples, was carried out on a nickel iron in which the nickel content increased from 0.15 to 1.51 per cent., whilst the molybdenum ran from 0.08 to 1.30. In this case sample number seven returned over 31 tons tensile with a 302 Brinell figure. The tables are somewhat unsatisfactory, as only the physical properties of the first and last samples are given, neither have the properties been graphed. The effect on chill, however, is made quite clear by photographs.

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The Case Hardening of Grey Iron by Beryllium*

By JOSEPH LAISSUS

Introduction

The author has recently shown how iron and ordinary carbon steels can be case hardened by beryllium.† The object of this Paper is to set out recent results obtained from the cementation of grey iron. The iron used for the experiments (T.C 3.53, Gr. 3.08, Si 2.47, Mn 0.66, S 0.033, P 0.354) was in the form of small cubes of 7 mm. each side and carefully polished. These cubes were placed in the centre of a cement made-up either of 98 per cent. purity beryllium or of ferro-beryllium containing 80 per cent. of beryllium. These two last products were highly pulverised and mixed with glucine 25 per cent. by volume. The conditions of the cementation were as follow:—*Duration*, 2½, 5 and 10 hours; *temperature*, 800, 900, 1,000, 1,100, and 1,150 deg. C. The researches were carried out at Laboratoire Général d'Essais Industriele in Paris.

Study of the Diffusion of Beryllium into Grey Iron

A.—Mechanism of the Diffusion.—From the temperature of 800 deg. C. it has been noticed that there is a very restricted superficial zone where there is a partial dispersion of the pearlite and graphite. If the time of heating and the temperature of cementation are varied, this zone is seen to develop into a solid solution (Fe-C-Be).

It then forms a hypoeutectic layer (solid solution + eutectic) then a eutectic layer (solid solution + combination) then a hypereutectic layer in which a combination appears (triple combination Fe^n Be^m C^p).

This last phase is difficult to observe because it is very fragile and flakes off in spite of the precautions taken to polish it.

TABLE I.—*Vickers' Hardness shown by Grey Iron cemented by Beryllium and Ferro-Beryllium for Ten Hours at Various Temperatures.*

Material or temperature.	Load used.					
	10 kgs.		30 kgs.		50 kgs.	
	Be.	Fe-Be.	Be.	Fe-Be.	Be.	Fe-Be.
Uncemented Grey Iron ..	—	—	—	—	194	194
800 deg.C.	124	187	131	156	—	151
900 deg.C.	—	960	—	375	—	296
1,000 deg.C.	—	1,561	—	927	—	398
1,100 deg.C.	349	1,312	406	441	395	420
1,150 deg.C.	—	421	—	366	—	362

B.—Influence of Temperature and Time.—The influence of the two factors of time and temperature on the cementation of grey iron by ferro-beryllium (80 per cent.) is of the following order:—

1. For a temperature of 800 deg. C. one notices a superficial skin of solid solution, the thickness of which increases with the time for an operation lasting ten hours; the thickness of this superficial zone is about six-hundredths to eight-hundredths of a millimetre. This external layer is poor in graphite and pearlite and is much less easily etched than the rest of the iron.

2. For a temperature of 900 deg. C. the zone of the solid solution, previously noted, is very clearly developed as a function of time. For example, one obtains the following:—

Condition of the process of diffusion. (Temperature-time.)	Thickness of the zone of the solid solution. (mm.)
900 deg. C. for 2½ hrs.	$\frac{1.5}{100}$ to $\frac{1.6}{100}$
900 deg. C. for 5 hrs.	$\frac{4.0}{100}$ to $\frac{4.5}{100}$

3. For a temperature of 1,000 deg. C. the layer of the external solid solution increases, the graphite disappears and islands of eutectic appear. If the time of the process is increased this hypoeutectic layer increases in importance and is transformed into a homogeneous eutectic layer. Starting-off with a process period of five hours, the presence of an external hypereutectic layer with combinations present is to be observed.

In order to gain an idea of the order of this diffusion, the following figures are given:—

Conditions of the process of diffusion. (Temperature-time.)	Thickness of the zone effected by the cementation. (mm.)
1,000 deg. C. for 2½ hrs. 1,000 deg. C. for 5 hrs.	$\frac{9.0}{100}$ to $\frac{1.2.5}{100}$. $\frac{2.7.0}{100}$ about:— Zone hypo. $\frac{2.2.2}{100}$ about. Zone eut. $\frac{4.5}{100}$ about. Zone hyper. $\frac{3}{100}$ about.

4. For temperatures from 1,100 and 1,150 deg. C. the results are not clear. The diffusion influences the whole of the sample and numerous dendritic islands characteristic of the approach of melting point are noted.

C.—Influence of the Composition of the Cement.—The results set out later show that ferro-beryllium used as a cement is much more active than 98 per cent. pure beryllium used under the same conditions.

Nature of cement.	Conditions of the diffusion process. (Temperature-time.)	Thickness of the zone effected by the cementation. (mm.)
Ferro-beryllium	1,000 deg. C. for 2½ hrs.	$\frac{9.0}{100}$ to $\frac{1.2.5}{100}$
Pure beryllium	1,000 deg. C. for 2½ hrs.	$\frac{4.0}{100}$ to $\frac{5.0}{100}$

The Properties of Grey Iron Cemented by Beryllium

A.—Hardness of the Cemented Layers.—The hardness of the case hardened layers has been determined by the Vickers' machine under varying loads. The results so found are set out in Table I. They show evidence of the following points:—

(1) Conditions of cementation being equal, the ferro-beryllium appears to give the higher degrees of hardness.

(2) The maximum hardness is reached at a temperature of 1,000 deg. C. This fact confirms the results set out in the preceding paragraph. Thus, it has been shown that at 1,000 deg. the combination hypereutectic layer is formed.

(3) The maximum hardness figure found, about 1,561 Vickers' hardness, is certainly one of the highest which has been disclosed up to the present on a metallurgical product. This result is particularly interesting, if it be compared with the hardness of uncemented iron of corresponding composition in its natural state, which will be about 194 Vickers'.

B.—Corrosion Results.—A few qualitative experiments have been carried out. They show that the cementation by beryllium does not improve the qualities of grey irons from the point of view of resistance to corrosion by chemical reagents, either acid or alkali.

On the other hand, the treatment considerably retards the formation of rust on the surface of grey iron when it is exposed to weather and either the action of ordinary or sea water.

General Conclusions

From the above it is possible to draw the following conclusions:—

(*a*) From the point of view of the mechanism of diffusion, the cementation of grey iron by beryllium is of the same order as that of iron and ordinary carbon steels cemented by the same element; with this difference, however, that the layers obtained are of much greater magnitude in the case of iron. The formation of the following constituents has been observed:—

1. Hypoeutectic zone (solid solution Fe-C-Be plus eutectic).

2. A eutectic zone (solid solution plus combination).

3. A hypereutectic zone (triple combination of indeterminate formulæ Fe^n Be^m C^p).

(*b*) From the point of view of novel properties conferred upon grey iron by the fact of its cementation by beryllium, it is possible to state that the surface hardness reached is of quite a remarkable character. The maximum figure obtained, 1,561 Vickers' hardness, exceeds those which have been considered as being the highest ever associated with metallurgical products. For instance, nitrided steels reached a figure of 1,100 to 1,200; and that found by the author in his previous works, 1,506 on eutectoid carbon steel cemented by beryllium at 1,000 deg. for 10 hrs.

As to resistance to corrosion, the results obtained with grey iron cemented by beryllium are identical with those published in connection with the author's researches on the cementation of carbon steels. The formation of rust by the action of either ordinary or salt water is retarded after having been cemented by beryllium, but this treatment is practically useless against the action of chemical re-agents attacking non-cemented grey iron.

* Paper presented to the Seventh International Congress of Mining Metallurgy and Applied Geology.

† C. R. Acad. Sc., Vol. 199, p. 1408.

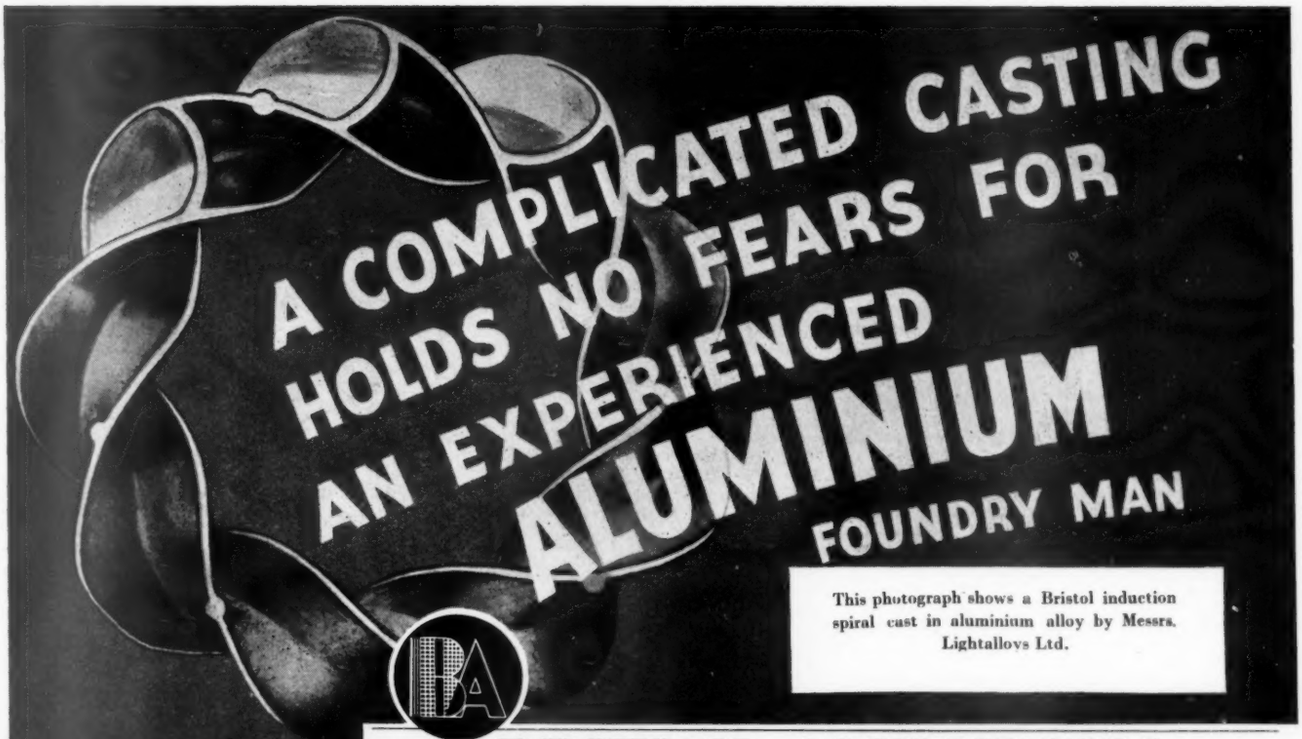
The Solidyna Roll-Casting Process

A new method for making sound castings in cast iron or steel, developed in the first instance for the production of steel rolls for sheet mills, is described by L. Quincy in an article in "Revue de Métallurgie," Vol. 33, No. 4, pages 265-279. The mould is lined with refractory material and, after being filled completely with molten metal, is closed and rotated about its long axis in a horizontal position until solidification is complete, an operation which may take 3 hours or more. As a result, an ingot is produced in which a large central shrinkage cavity, traversing the length of the ingot, is surrounded by perfectly sound, fine-grained metal, free from inclusions and all types of cavities.

An important difference exists between this process and centrifugal casting, as ordinarily practised, in respect to the mechanism of solidification. In the "Solidyna" process, since the central cavity is caused by shrinkage alone and does not form until solidification occurs in the outer layers, and since there is no communication between the cavity and the surrounding air, solidification progresses entirely from the periphery to the centre of the casting. In ordinary centrifugal casting a skin forms on the interior before solidification is complete.

It is claimed that exceptionally fine castings, free from cracks and inclusions, and with no longitudinal segregation, are produced by this method of "dynamic solidification." All impurities, including gases, are brought to the centre and can be removed, if desired, by a trepanning operation. A large number of rolls have already been made by the process on a commercial scale, the largest being a steel roll, 4 ft. in diameter, 10 ft. 6 in. long, weighing about 30 tons, for use in a blooming train.

MANGANESE PRODUCTION in the Union of South Africa showed a sharp increase during July, 22,018 tons of 48 per cent. being produced compared with 13,761 tons of 48 per cent. in June.


A COMPLICATED CASTING
HOLDS NO FEARS FOR
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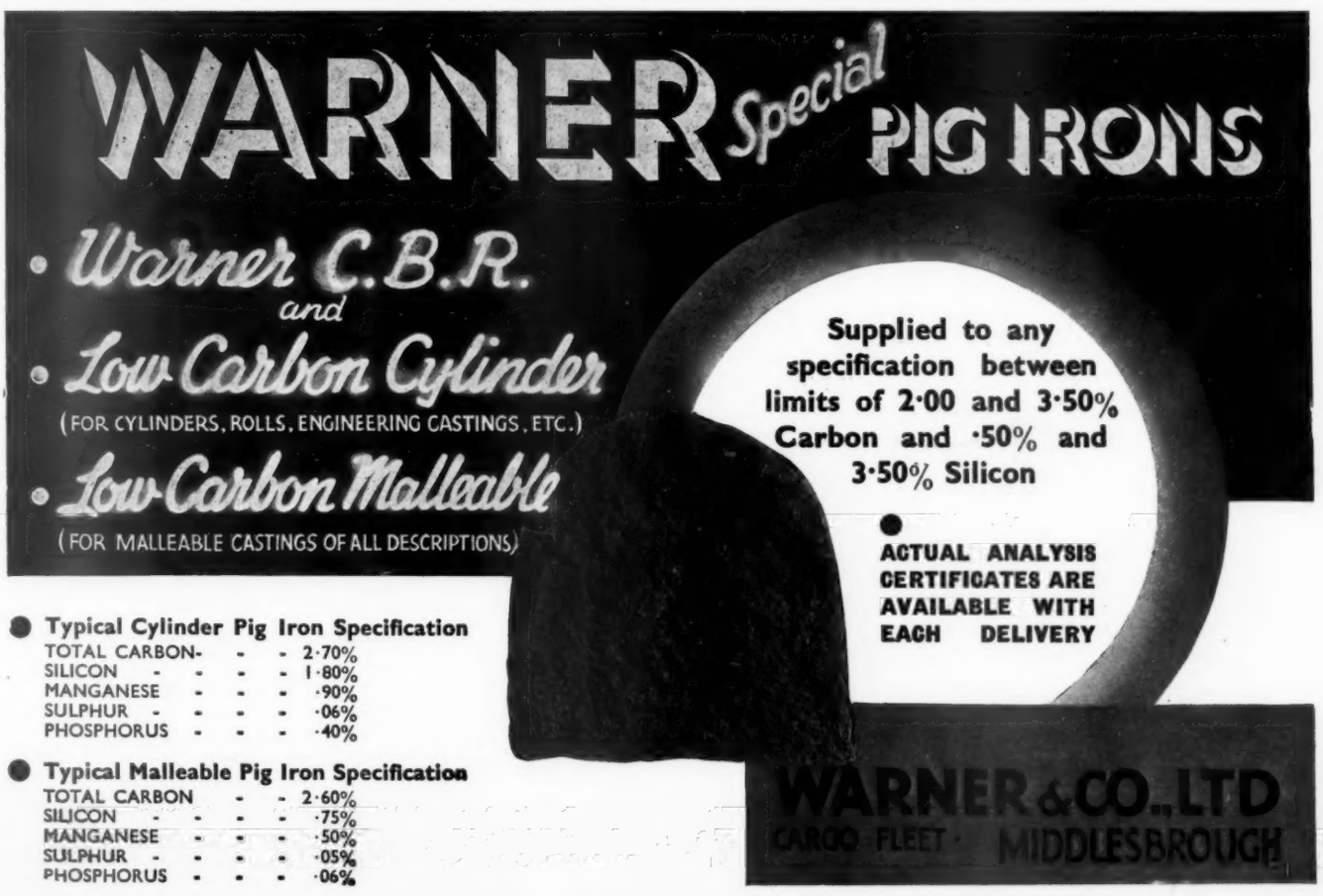
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The Week's News in Brief

Trade Talk

THE FREDK. CRANE CHEMICAL COMPANY, LIMITED, inform us that their address is now Alma Street, Smethwick, Birmingham.

THE TELEPHONE NUMBER of the head office of George Cohen, Sons & Company, Limited, at 600, Commercial Road, London, E.14, has been changed from East 6060 to Stepney Green 3434.

THE BELGIAN STEELWORKS, Soc. Métallurgique d'Espérance-Longdoz, has formed a new company, Soc. Commerciale d'Espérance-Longdoz, at Liège, with a capital of 100,000 fcs., to trade in iron and steel products.

BY MUTUAL AGREEMENT, R. G. Holland & Company, Limited, Canal Steelworks, and George Senior & Sons, Limited, Swedish iron and steel merchants; of Ponds Forge, Sheffield, after working in conjunction during the past eight years, have decided to revert to entire independence.

A FACTORY for the manufacture of a fire- and heat-resisting electric cable to French patents is to be established at Hebburn-on-Tyne. A new company, the Pyrotenax Company, of London, has taken over the manufacturing rights of the cable and is to build a factory in Hedgley Road, Hebburn.

FOLLOWING A STRIKE of labourers at a Kirkintilloch foundry, the case was taken up by the National Union of Foundry Workers, whose organiser, Mr. John McBain, negotiated an agreement with the employers at a conference called by the Ministry of Labour. The terms of settlement provide for a minimum wage of 44s. 1d. for labourers.

THE NEW SESSION of the Sir John Cass Technical Institute, Jewry Street, Aldgate, London, E.C.3, which extends over 36 weeks, will begin on Monday, September 21. The Department of Metallurgy provides a series of comprehensive courses in metallurgy and a course in foundry practice which meets the requirements of students desiring to enter the City and Guilds of London Institute Examination in Foundry Practice.

THE DIRECTORS OF Davy Bros., Limited, Sheffield, announce that the company has acquired the business of the British Chilled Roll & Engineering Company, Limited, Empire Works, Haverton Hill, Middlesbrough. The board of directors of the British Chilled Roll & Engineering Company has been reconstituted, and now comprises Mr. E. J. Fox (chairman), Mr. S. V. Toy and Mr. D. F. Campbell. Mr. S. V. Toy will act as technical director and Mr. H. B. Toy remains in a consultative capacity.

A STRIKE IN THE pipe-moulding shop of Whyman's Foundry Company, Limited, of Warrington, which had involved between 80 and 100 moulders and their assistants, has ended. The moulders ceased work as a protest against a recent appointment of an outside man as a master moulder. It had been the custom, when a moulder left, to appoint his assistant to the position, but this practice, it is stated, was not observed in the recent case. It is understood that an amicable agreement has been reached, and that the man who was appointed still holds his position.

THE STANTON IRONWORKS COMPANY, LIMITED, are increasing their blast-furnace capacity by making it possible to blow an additional furnace at their Stanton Works and an additional furnace at their Holwell Works. When these additions are completed, they will be able to work at the same time five furnaces at Stanton (instead of four) and four furnaces at Holwell (instead of three), in addition, of course, to the two recently-erected furnaces at Wellingborough. A mechanical pig-casting machine is being installed at Holwell for the benefit of customers who require foundry and forge pig-iron free from sand.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Mayer, Newman & Company, Limited, Arundel House, Arundel Street, Strand, London, W.C.2.—Capital, £10,000. Scrap iron and metal merchants, etc. Directors: O. Mayer and H. A. Newman.

Personal

MR. ARNOLD CARR, manager of the foundry supplies department of Thos. W. Ward, Limited, Albion Works, Sheffield, informs us that, as and from September 17, his private address will be 122, Furniss Avenue, Dore, Sheffield.

MR. J. T. BATEY, who retired from the managing directorship of R. & W. Hawthorn, Leslie & Company, Limited, Hebburn-on-Tyne, in June, relinquished his seat on the board of directors at the company's annual meeting on Tuesday.

MR. ERNEST BLACKSTONE AND MR. HAROLD BLACKSTONE have retired from the board of Blackstone & Company, Limited, the Stamford engineering firm, but will continue to serve in an advisory capacity. As reported last week MAJOR CHARLES PRATT has joined the board.

SIR HAROLD CARPENTER, F.R.S., President of the Iron and Steel Institute, has been obliged, for reasons of health, to cancel his intention to take part in the autumn meeting of the Institute at Düsseldorf next week. Mr. James Henderson, J.P., has been nominated Acting President. Mr. Henderson is honorary treasurer of the Institute, a Past-President of the British Iron and Steel Federation, deputy-chairman of the Appleby Frodingham Steel Company, Limited, and director of the United Steel Companies, Limited.

Will

MACLAREN, COLONEL ROBERT, a director of A. W. Smith & Company, Limited, engineers and sugar machinery manufacturers, Glasgow £45,596

Obituary

MR. F. ATKIN, of Erdington, Birmingham, a representative of Thos. W. Ward, Limited, of Sheffield, died on September 8.

MR. THOMAS C. MCDONOGH, whose death has occurred in Paris, was the head of T. McDonogh & Sons, of Galway, iron merchants. The firm this year celebrated its centenary.

MR. WILLIAM AITKENHEAD, O.B.E., whose death occurred in Glasgow recently, was for 40 years in the employment of G. & J. Weir, Limited, of Cathcart. He held the position of works manager for 30 years, retiring in 1928.

Company Reports

Imperial Chemical Industries, Limited. — Interim dividend of 2½ per cent. actual on the ordinary stock.

Alexander Duckham & Company, Limited.—Interim dividend of 5 per cent. on the ordinary shares.

British Ropes, Limited.—Interim dividend on the 7 per cent. non-cumulative preferred ordinary shares for the period from January 1 to June 30, 1936.

R. & W. Hawthorn, Leslie & Company, Limited. —Net profit for year ended June 30, £25,647; brought in, £14,951; dividend on the ordinary shares of 6 per cent., £21,496; carried forward, £19,102.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"DUREN."—Cast-iron firebars. Duren Firebar Company, Limited, 57, Victoria Street, London, S.W.1.

"TWO-RAM QUALITY" (DEVICE).—Tool steel and steel alloys and machinery. Biram & Company, Limited, Drayton House, Gordon Street, London, W.C.1.

"WHITE OX BRAND" (DEVICE).—Oxide of tin. O. T. Lempriere & Company Proprietary, Limited, c/o Boult, Wade & Tennant, 112, Hatton Garden, London, E.C.1.

The Complex Interdependence of the Properties of Light Alloys

(Concluded from page 214.)

and difficulties. For these alloys monobloc design must be abandoned. Alpax, on the other hand, is unsuitable for designs which require the assembly of a large number of small units, on account of its poor resistance to high local stresses, particularly at right angles to the assembly bolts.

Thermodynamic Factors

Breakdowns of motors are sometimes attributed to faulty material, when the basic cause is to be found in one of the numerous thermodynamic factors of its functioning. Systematic piston seizure, for example, has at times been traced to the use of inferior fuel. Again, corrosion of magnesium-alloy petrol tanks by additions of tetraethyl lead to the fuel, resulted in decomposition of this anti-detonant, so that, until a chemical remedy was found, the metal of the tank was accused of reducing the possible compression ratio.

On the other hand, the thermodynamic factors are, themselves, affected by the appearance of new alloys. The use of beryllium copper alloys of high thermal conductivity, for exhaust valves, has enabled these to work at lower temperature, and so increased the life of the engine.

Influence of Modulus of Elasticity

The strength and elastic limit of light alloys has been increased, while the modulus of elasticity has remained almost unchanged. The secondary factor of deformation consequently governs the factor of safety to an increasing extent. For a casting of given design there is a particular value of the elastic limit of the material, which it is useless to exceed.

The importance of the modulus of elasticity was shown in the case of aero engines, having their cylinders in line. These were subject to systematic breaking of crank-shafts, due to deformation of the aluminium-alloy crank-cases. When the latter were made more rigid the trouble ceased, but it reappeared when they were cast from the same patterns in magnesium alloy of different modulus of elasticity.

Effects of Use

In many constructions the flexibility and natural period of vibration vary with time. Particularly in the case of assembled units, where stress concentrations occur at the joints, the fatigue limit of the material is all-important. It must be emphasised that it is not only the parts transmitting power which are subject to fatigue, but also the whole supporting structure—especially when this is not of monobloc design.

Conclusion

Metallurgists are warned against the unconsidered application of new alloys, and engineers against hasty condemnation of the materials with which they are supplied. In spite of careful forethought metallurgists and engineers will encounter unsuitable applications which will throw a prematurely advertised material into disfavour. This is the explanation of the amazing set-backs to be remembered in the history of the most logical new developments.

Forthcoming Events

SEPTEMBER 14-18.
Institute of Metals:—Annual Conference in Paris.

SEPTEMBER 16-25.
International Foundry Congress and Foundry Exhibition, in Düsseldorf.

SEPTEMBER 21-26.
Iron and Steel Institute:—Autumn Meeting in Düsseldorf.

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. . . . it contains information regarding insulation for every user of heat.

General Refractories manufacture three insulating products which are of vital importance to every user of heat. This new booklet describes these three products—Insulite and Amberlite bricks and Insulite Concrete—and also gives instances of how 80% of waste heat may be saved and fuel costs reduced by as much as 20% . . . these products may be used for the heat insulation of open hearth furnaces and regenerator chambers, blast furnace plant (including Cowper stoves), annealing and heat treatment furnaces, blast pipes, hot gas mains, etc., ceramic kilns and ovens, glass furnaces, boiler settings, economisers, and super-heaters, enamelling and general furnaces—whether heated by solid fuel, gas, oil or electricity. All the necessary technical information is also included, so we strongly advise that you write to-day for a free copy.

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Scottish Office:
156, St. Vincent St.,
Glasgow
Telephone: 5250
Telegrams:
"Genefax, Glasgow"

South Wales Office:
11, Wind St.,
Swansea
Telephone: 3680
Telegrams:
"Genefax, Swansea"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

Raw Material Markets

The possibility of a shortage of supplies of pig-iron during the autumn is becoming more of a probability. Consumers have heavy requirements and they are endeavouring to secure large stocks as a precaution. Deliveries are about maintained, but the surplus material does not amount to any considerable tonnage. Constructional steelwork is heavily inquired for, as are most other descriptions. Export trade has shown an improvement.

Pig-Iron

MIDDLESBROUGH.—Active conditions prevail in this area, and, in view of the possibility of a shortage in pig-iron supplies later on, users are anxious to build up large stocks. Their efforts have not been too successful. Makers succeed in satisfying consumers' immediate needs, but hesitate to accept further specifications for large tonnages. Business is only entered into up to the end of the year at current prices and any contracts involving deliveries in 1937 are transacted under the condition that higher prices may have to be paid. Quotations for No. 3 Cleveland G.M.B. are 75s. per ton in the Middlesbrough and Falkirk districts, 77s. on the North-East Coast, and 78s. on Clydeside.

The market for East Coast hematite is very firm and the current production, which is reported to be almost as large as that of the West Coast, is readily taken up. Inquiries for new business are heavy, but makers are reluctant to increase their commitments. Two additional furnaces at Seaton Carew are being prepared, and their outputs will be readily taken up. East Coast mixed numbers are quoted at 85s. per ton, less a rebate of 5s. to purchasers who buy solely from the Hematite Makers' Association. A revision of these prices is anticipated after the turn of the year.

LANCASHIRE.—Business in pig-iron has been on a better scale during the past week. Though deliveries are heavy, consumers are drawing supplies from their stocks. Machine-tool makers are taking up supplies regularly, while the general and speciality engineers and the jobbing foundries are working to capacity. Offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 iron, equal to Derbyshire, are all on the basis of 83s. per ton for delivery in the Lancashire price zone, with Northants at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s. per ton. There is a steady call for West Coast hematite at 93s. 6d. per ton, with East Coast at 93s., both delivered equal to Manchester. Scottish No. 3 foundry iron is 91s. 6d. per ton, delivered this district.

MIDLANDS.—New business has been transacted on a fair scale recently, and some users have booked supplies up to the end of March, 1937. It is difficult, however, to purchase more than a proportion of the total needs in most cases. For delivery at Birmingham and Black Country stations, Northamptonshire No. 3 is quoted at 77s. 6d. and Derbyshire, Lincolnshire and North Staffordshire No. 3 at 80s., these figures being subject to a small sliding-scale rebate to large users. Local iron-foundries are active, while the general engineers and jobbing founders are taking up satisfactory quantities of special irons, the prices of which vary considerably. Medium-phosphorus is quoted at 82s. 6d. to 90s., low-phosphorus at 92s. 6d. to 100s., with refined iron at £6 10s. to £8 10s., according to analysis. Forge pig-iron, which is charged at 3s. to 5s. below ordinary No. 3 foundry, is receiving a large number of inquiries, and a shortage is being experienced at some of the furnaces. Although makers of hematite have expressed their willingness to enter into business up to the end of February at current prices, there are several producers that are already heavily committed and are consequently reluctant to add to these responsibilities. Deliveries against existing contracts are accounting for substantial tonnages. West Coast mixed numbers are quoted at £4 17s., East Coast No. 3 at £4 16s., and Welsh mixed numbers at £4 15s. 6d., less 5s. rebate, delivered local stations. An additional 1s. 6d. per ton is charged for delivery into works in 10-ton lots.

SCOTLAND.—All descriptions of iron remain in good demand in this area, but only a comparatively small number of new contracts have been arranged, owing to the heavy commitments already undertaken by producers. No. 1 foundry is quoted at 81s. 6d., with No. 3 at 79s., f.o.t. furnaces. Prices of Cleveland iron are also unaltered at 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow. Supplies are unobtainable, however, and users are compelled to utilise local material or Midland iron for their needs. A satisfactory demand is experienced for hematite iron, East Coast, West Coast and Scottish grades remaining at 85s. 6d. per ton, less 5s. rebate; with basic, British and Indian, 75s., less 5s. rebate, all f.o.t. furnaces.

Coke

There has, as yet, been no increase in prices on the foundry-coke market, but conditions remain very firm. Most consumers are well covered for their autumn and winter requirements. For delivery in the Birmingham district, best Durham coke is quoted at 40s. to 42s. 6d., with Welsh at 40s. to 50s. per ton.

Steel

The broadening in the demand for steel materials continues, and one of the features of the market is the pressure which is being exercised by consumers to secure delivery, says the official report of the London Iron and Steel Exchange. This applies to all steel materials in most common use, and to many special steel products. Consumers find it difficult to place orders for anything approaching near delivery, and in many cases the works are behind in their deliveries against contracts. In the semi-finished steel department the whole of the production is passing at once into consumption, and consumers find it difficult to cover their full requirements. In this department the demand has expanded since the autumn season commenced, and fears are expressed that a shortage may cause difficulties later on. Business in finished steel continues upon an active scale, and practically all the works are operating at capacity. Heavy quantities of structural steel are being produced, but the makers, nevertheless, are hard pressed to satisfy the demand.

Scrap

Home supplies of heavy steel scrap are in heavy request on the Cleveland market now that imported material is less plentiful. The price is generally 57s. 6d. per ton, although up to 60s. has been paid in some cases. Deliveries of cast-iron scrap against existing contracts have been held up and merchants have suffered some inconvenience. Machinery quality is quoted at 65s. and foundry grade at 62s. 6d. up to 65s. The Lancashire market is very firm, with prices showing a rising tendency. Cast-iron scrap is well taken up at from 67s. 6d. to 70s. per ton, delivered to Lancashire foundries. Wrought-iron scrap is at 65s., delivered to local works, with heavy melting steel scrap at from 57s. 6d. to 60s. per ton, delivered Sheffield basis. Consumption on the Scottish market is good and values are firm. First-quality heavy steel scrap is at 57s. 6d., with heavy iron and steel scrap mixed, in furnace sizes, at 52s. 6d. Wrought-iron piling scrap is on offer around 69s. to 70s., while 72s. 6d. to 73s. 6d. is being paid for special quality. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is at 69s. to 70s., while 5s. per ton less is charged for ordinary heavy cast-iron scrap, to the same specification, delivered f.o.t. consumers' works.

Metals

Copper.—Prospects for this market are excellent. Consumption is already heavy and is reported to be increasing. Substantial tonnages are changing hands on industrial account in this country. With regard to the price position in the United States it is believed that the opposition from the Kennecott Corporation to a rise will be overcome and that the domestic quotation will be raised by ¼ cent to 10 cents per lb. In connection with the recent decision to increase outputs by 5 per cent. of standard or to decrease the curtailment of production from 25 per cent. to 20 per cent., the weekly market report issued by Brandeis, Goldschmidt & Company, Limited, states that "the increase in production, which follows on a similar one announced as from August 1, is reasonable, though whether the present is the proper time is a matter of opinion. It is satisfactory to note that under the copper restriction agreement producers are endeavouring to prevent undue price fluctuations and to maintain the market in a healthy condition. So long as consumption is increasing and commodity prices are tending upwards, the position will remain sound. World stocks are, however, still heavy and, if they were not held firmly, would provide an element of instability. It is important that the balance between production and consumption should continue to be carefully watched. In the meantime, domestic copper in the United States has been firm at 9.75 cents. It remains to be seen whether producers in the United States will now decide on a further increase in production and what effect this may have on the European price, which is now about on a parity with the domestic level."

Daily market prices :—

Cash.—Thursday, £38 18s. 9d. to £39; Friday, £39 to £39 2s. 6d.; Monday, £39 3s. 9d. to £39 6s. 3d.; Tuesday, £39 1s. 3d. to £39 2s. 6d.; Wednesday, £38 18s. 9d. to £39.

Three Months.—Thursday, £39 3s. 9d. to £39 5s.; Friday, £39 5s. to £39 6s. 3d.; Monday, £39 7s. 6d. to £39 8s. 9d.; Tuesday, £39 6s. 3d. to £39 7s. 6d.; Wednesday, £39 2s. 6d. to £39 3s. 9d.

Tin.—There is little of importance to report this week and the market has remained featureless, though prices have fluctuated. Continental consumers are very quiet, chiefly owing to the disturbed condition of Spain, but users in this country and in the United States are active. It is generally believed that there will be no advance made in the quota when the International Tin Committee meet in London on September 18, although this is by no means certain. Intervention by Mr. Van den Broek has been the cause of a renewal of negotiations in connection with the proposal to merge the Banka and Billiton tin mines. The strike at the Hoboken smelter has not been settled.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £195 10s. to £195 15s.; Friday, £193 to £193 5s.; Monday, £198 to £198 10s.; Tuesday, £196 10s. to £197; Wednesday, £194 5s. to £194 15s.

Three Months.—Thursday, £192 5s. to £192 10s.; Friday, £190 2s. 6d. to £190 7s. 6d.; Monday, £194 5s. to £194 10s.; Tuesday, £193 15s. to £194; Wednesday, £191 15s. to £192.

Spelter.—This market, which has long held the reputation of being very sensitive, has reacted favourably on the belief that there will shortly be a meeting in connection with the re-establishment of the international zinc cartel. However, official information is still unobtainable, and it would be unwise to base too much hope on this latest rumour. Buying has been fair, with brassmakers very active, but the galvanisers have only small requirements. The oxide trade is in a favourable position at the present time. The German building trade is in a state of great activity. The demand for zinc sheets, chiefly from Holland and Belgium, is considerable.

Official quotations were as follow :—

Ordinary. — Thursday, £14 5s.; Friday, £14 2s. 6d.; Monday, £14 6s. 3d.; Tuesday, £14 6s. 3d.; Wednesday, £14 8s. 9d.

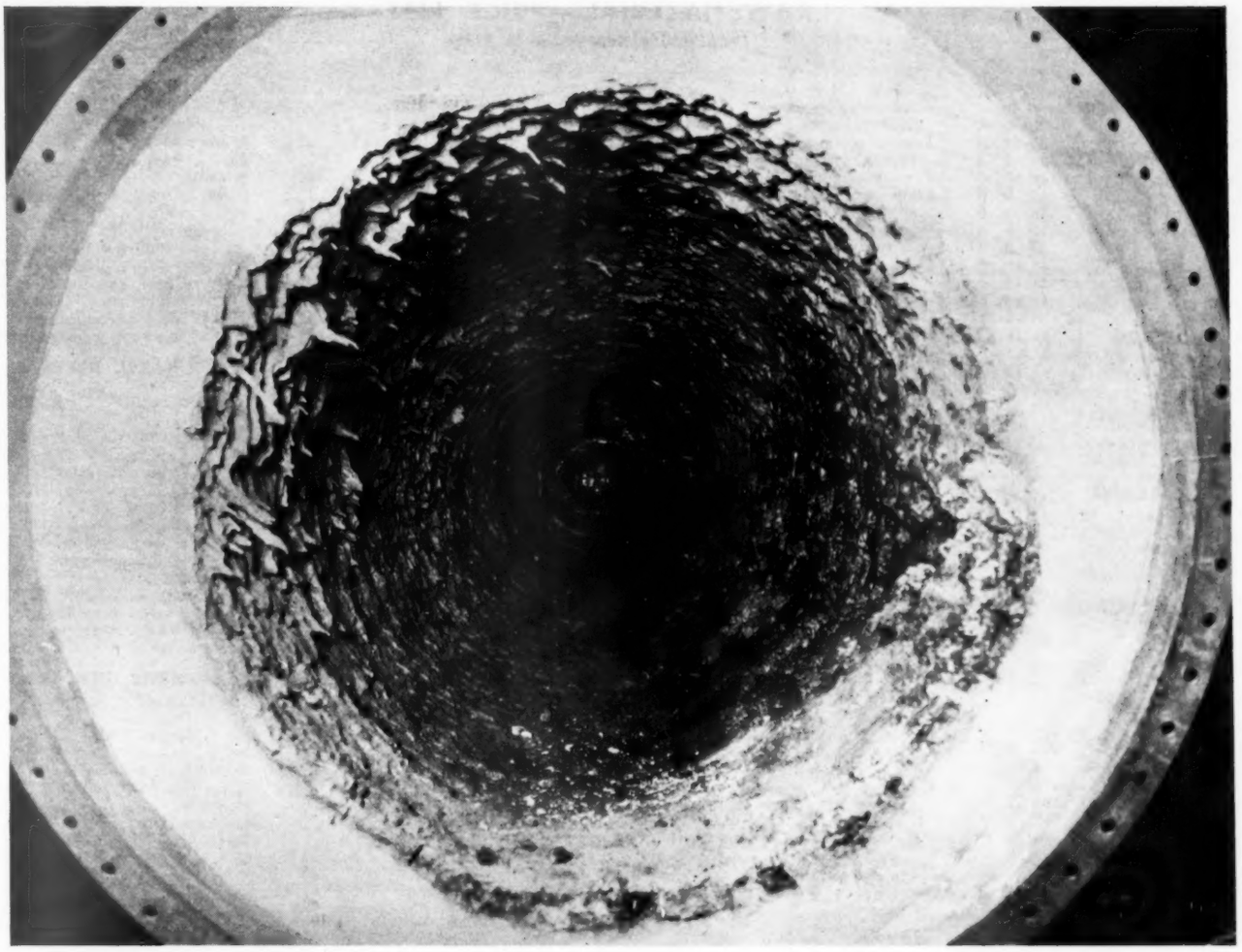
Lead.—The turnover in this metal has been heavy during the past week, and the outlook for the market is entirely satisfactory. A meeting of world lead producers is to be held in London this month. This is typical of the policy of informal co-operation among lead producers, which has had very beneficial effects on the market.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £18 5s.; Friday, £18 6s. 3d.; Monday, £18 6s. 3d.; Tuesday, £18 10s.; Wednesday, £18 11s. 3d.

A Light Alloy Reference Index

A particularly useful service has been given to the founder of light alloys by the publication of the annual indices to "Light Metals Research," covering both authors and subjects. The extent of the field covered can well be gauged by the fact that it absorbs 108 pages. Apart from its intrinsic merit as an index covering July, 1935, to July, 1936, it is a model worth studying by those whose duty involves the indexing of technical data.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles. This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please write for further particulars to the sole manufacturers:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION

RAW MATERIALS—PRICE LIST

(Wednesday, September 16, 1936)

COPPER

	£	s.	d.
Standard cash	38	18	9
Three months	39	2	6
Electrolytic	43	5	0
Tough	42	5	0
Best selected	42	15	0
Sheets	70	0	0
India	53	0	0
Wire bars	43	15	0
Ingot bars	43	15	0
H.C. wire rods	47	10	0
Off. av. cash, Aug.	38	5	11½
Do., 3 mths., Aug.	38	11	3⅜
Do., Sttlmnt., Aug.	38	5	9
Do., Electro, Aug.	42	13	0
Do., B.S., Aug.	42	5	0
Do., wire bars, Aug.	42	18	6
Solid drawn tubes			10¾d.
Brazed tubes			10¾d.
Wire			6½d.

BRASS

Solid drawn tubes	9¾d.
Brazed tubes	11¾d.
Rods, drawn	9d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8½d.
Wire	8d.
Rolled metal	7⅞d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5⅞d.
Do. 4 × 3 Sheets	5⅞d.

TIN

	£	s.	d.
Standard cash	194	5	0
Three months	191	15	0
English	194	10	0
Bars	196	10	0
Straits	196	5	0
Australian	194	5	0
Eastern	195	5	0
Banca (nom.)	196	5	0
Off. av. cash, Aug.	183	17	7½
Do., 3 mths., Aug.	180	17	1½
Do., Sttlmt., Aug.	183	17	0

SPELTER

	£	s.	d.
Ordinary	14	8	9
Remelted	13	10	0
Hard	11	15	0
Electro 99.9	16	8	9
English	15	2	6
India	12	15	0
Zinc dust	19	15	0
Zinc ashes	4	10	0
Off. aver., Aug.	13	12	10½
Aver. spot, Aug.	13	10	6¼

LEAD

	£	s.	d.
Soft foreign ppt.	18	11	3
Empire	19	5	0
English	20	10	0
Off. average, Aug.	16	16	3¾
Average spot, Aug.	16	15	5¼

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	24	0	0	to	24	10	0
Do., V.M. ex-whse.	24	0	0	to	24	10	0
Rods					25	10	0

ANTIMONY

English	64	10	0	to	65	10	0
Chinese, ex-whse.					54	0	0
Crude, c.i.f.					25	0	0

QUICKSILVER

Quicksilver	12	18	6	to	12	19	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—							
25%					8	17	6
45/50%	11	10	0	to	12	15	0
75%	16	12	6	to	17	17	6
Ferro-vanadium—							
35/50%					12/8 lb. Va.		
Ferro-molybdenum—							
70/75% carbon-free					4/6 lb. Mo.		
Ferro-titanium—							
20/25% carbon-free					9d. lb.		
Ferro-phosphorus, 20/25%					£21 to £22		
Ferro-tungsten—							
80/85%					3/1¼ lb.		
Tungsten metal powder—							
98/99%					3/3 lb.		
Ferro-chrome—							
2/4% car.					33	0	0
4/6% car.					21	10	0
6/8% car.					21	0	0
8/10% car.					21	0	0
Ferro-chrome—							
Max. 2% car.					33	10	0
Max. 1% car.					36	5	0
Max. 0.50% car.					37	5	0
70% carbon-free					9½d. lb.		
Nickel—99.5/100%					£200 to £205		
"F" nickel shot					£184	0	0
Ferro-cobalt, 98/99%					6/3 to 6/9 lb.		
Metallic chromium—							
96/98%					2/5 lb.		
Ferro-manganese—							
76/80% loose	£11	5	0	to	11	15	0
76/80% packed	£12	5	0	to	12	15	0
76/80% export					£10	5	0
Metallic manganese—							
94/96% carbon-free					1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/32 in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel	3	3	0	to	3	4	0
Mixed iron and steel	2	18	0	to	3	0	0
Heavy cast iron	2	18	6	to	3	0	0
Good machinery	3	2	0	to	3	4	0
Cleveland—							
Heavy steel	2	17	6	to	3	0	0
Steel turnings	2	0	0	to	2	5	0
Heavy cast iron	3	2	6	to	3	5	0
Heavy machinery	3	5	0	to	3	7	6
Midlands—							
Light cast-iron scrap	2	12	6	to	2	15	0
Heavy wrought iron					3	5	0
Steel turnings					2	0	0
Scotland—							
Heavy steel					2	17	6
Ordinary cast iron	3	4	0	to	3	5	0
Engineers' turnings					2	2	6
Cast-iron borings					1	17	9
Wrot-iron piling	3	9	0	to	3	10	0
Heavy machinery	3	9	0	to	3	10	0

London—Merchants' buying prices, delivered yard.

Copper (clean)	32	0	0
Brass	20	0	0
Lead (less usual draft)	16	10	0
Tea lead	12	0	0
Zinc	8	15	0
New aluminium cuttings	74	0	0
Braziery copper	29	0	0
Gunmetal	30	0	0
Hollow pewter	142	0	0
Shaped black pewter	107	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/–
,, No. 4	74/–
Forge No. 4	74/–
Hematite No. 1	85/6*
Hematite M/Nos.	85/–*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/–*
Malleable iron d/d Birm.	125/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/–
,, No. 3 fdry.	80/–
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/–
,, fdry. No. 3	80/–
,, fdry. No. 1	83/–
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/–
Cleveland No. 3, Glasgow	78/–
,, ,, Falkirk	75/–
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/–*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/–
Staffs fdry. No. 3	83/–
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	91/6
Clyde, No. 3	91/6
Monkland, No. 3	91/6
Summerlee, No. 3	91/6
Eglinton, No. 3	91/6
Gartsherrie, No. 3	91/6
Shotts, No. 3	91/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)					10	10	0
Nut and bolt iron	8	17	6	to	9	7	6
Hoops					11	7	6 and up.
Marked bars (Staffs) f.o.t.					13	0	0
Gas strip					11	7	6 and up.
Bolts and nuts, ¾ in. × 4 in.					16	0	0 and up.
Steel—							
Plates, ship, etc.	9	7	6	to	9	10	0
Boiler plts.	9	17	6	to	10	0	0
Chequer plts.					11	0	0
Angles					9	0	0
Tees					10	0	0
Joists					9	7	6
Rounds and squares, 3 in. to 5½ in.					10	0	0
Rounds under 3 in. to ⅜ in. (Untested)					9	7	0
Flats—8 in. wide and over					9	5	0
,, under 8 in. and over 5 in.					9	10	0
Rails, heavy	8	5	0	to	8	10	0
Fishplates					12	10	0
Hoops (Staffs)					10	2	0
Black sheets, 24g. (4-t. lots)					12	0	0
Galv. cor. shts. (,,)					14	0	0
Galv. flat shts. (,,)					14	10	0
Galv. fencing wire, 8g. plain					15	0	0
Billets, soft					6	2	6
Billets, hard	7	2	6	to	7	7	6
Sheet bars					6	0	0
Tin bars					6	0	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	12d.
Tubes	14d.
Castings	12½d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.58
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	30.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.50
Sheets, galv., No. 24	3.20
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/– to 32/–
,, furnace	24/6 to 25/–
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/–
,, furnace	25/– to 26/–

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/9
,,	28×20 ,,		37/6
,,	20×10 ,,		26/9 to 27/–
,,	18¾×14 ,,		19/6
C.W.	20×14 ,,		15/9
,,	28×20 ,,		34/–
,,	20×10 ,,		22/9
,,	18¾×14 ,,		15/6 to 15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	0	0	to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	0	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£25	0	0	to	£28	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
Sept. 10 ..	38	18	9	inc.	10/-
„ 11 ..	39	0	0	„	1/3
„ 14 ..	39	3	9	„	3/9
„ 15 ..	39	1	3	dec.	2/6
„ 16 ..	38	18	9	„	2/6

Electrolytic Copper

	£	s.	d.		
Sept. 10 ..	43	0	0	No	change
„ 11 ..	43	5	0	inc.	5/-
„ 14 ..	43	10	0	„	5/-
„ 15 ..	43	10	0	No	change
„ 16 ..	43	5	0	dec.	5/-

Standard Tin (cash)

	£	s.	d.		
Sept. 10 ..	195	10	0	inc.	30/-
„ 11 ..	193	0	0	dec.	50/-
„ 14 ..	198	0	0	inc.	100/-
„ 15 ..	196	10	0	dec.	30/-
„ 16 ..	194	5	0	„	45/-

Tin (English ingots)

	£	s.	d.		
Sept. 10 ..	195	10	0	inc.	25/-
„ 11 ..	193	0	0	dec.	50/-
„ 14 ..	198	5	0	inc.	105/-
„ 15 ..	196	15	0	dec.	30/-
„ 16 ..	194	10	0	„	45/-

Spelter (ordinary)

	£	s.	d.		
Sept. 10 ..	14	5	0	inc.	5/-
„ 11 ..	14	2	6	dec.	2/6
„ 14 ..	14	6	3	inc.	3/9
„ 15 ..	14	6	3	No	change
„ 16 ..	14	8	9	inc.	2/6

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
Sept. 10 ..	16	5	0	inc.	5/-
„ 11 ..	16	2	6	dec.	2/6
„ 14 ..	16	6	3	inc.	3/9
„ 15 ..	16	6	3	No	change
„ 16 ..	16	8	9	inc.	2/6

Lead (soft foreign, prompt)

	£	s.	d.		
Sept. 10 ..	18	5	0	inc.	6/3
„ 11 ..	18	6	3	„	1/3
„ 14 ..	18	6	3	No	change
„ 15 ..	18	10	0	inc.	3/9
„ 16 ..	18	11	3	„	1/3

Lead (English)

	£	s.	d.		
Sept. 10 ..	20	5	0	inc.	5/-
„ 11 ..	20	5	0	No	change
„ 14 ..	20	5	0	„	„
„ 15 ..	20	10	0	inc.	5/-
„ 16 ..	20	10	0	No	change

Imports and Exports of Pig-iron, Castings, etc., in August and the Eight Months 1936, compared with August and the Eight Months 1935.

	August.		Eight months.		August.		Eight months.	
	1935.	1936.	1935.	1936.	1935.	1936.	1935.	1936.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	6,966	18,415	50,162	72,491	20,664	58,233	149,872	227,241
„ Foreign Countries	1,491	9,826	9,499	41,075	9,117	32,687	55,902	160,522
Total	8,457	28,241	59,661	113,566	29,781	90,920	205,774	387,763
Castings and forgings	391	383	2,064	5,046	9,812	12,476	53,063	173,227
Cast pipes and fittings	123	144	1,079	1,002	3,724	5,357	26,400	34,506
Stoves and grates, etc.	66	28	849	548	6,589	3,650	70,475	51,591
Baths	635	700	4,729	4,969	15,188	16,790	125,597	122,393
Hollow-ware, all kinds	211	252	1,689	2,325	13,443	14,772	112,799	127,902
Exports.								
Pig-iron, forge and foundry	7,391	6,495	62,918	39,323	26,576	24,486	219,294	148,856
„ acid	3,916	3,268	33,444	25,714	12,262	12,124	108,348	93,025
„ basic	—	40	231	148	—	236	727	793
Total	11,307	9,803	96,593	65,185	38,838	36,846	328,369	242,674
Castings and forgings	400	358	2,911	2,785	12,123	13,037	107,568	105,368
Cast pipes and fittings, up to 6 in. diameter	5,549	4,861	38,253	37,061	61,905	53,610	422,785	415,049
„ „ „ over 6 in.	1,723	2,337	23,487	26,267	14,436	20,312	183,645	215,403
Stoves, grates, etc.	794	907	5,618	6,647	39,921	44,385	281,863	340,249
Sanitary cisterns	214	214	2,035	2,007	6,591	6,537	59,501	62,354
Bedsteads, including tubes therefor	358	357	2,800	3,158	13,897	13,118	103,947	118,496
Cast hollow-ware	288	348	2,542	3,547	10,510	13,828	96,956	128,525

WILLIAM JACKS & COMPANY,
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
13, RUMFORD STREET, LIVERPOOL.

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FERRO-SILICON—FERRO-CHROME

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ZETLAND ROAD, MIDDLESBROUGH.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY Foreman desires change. Broad experience with machine tool and general engineering castings up to 30 tons; modern production methods. Real live man. M.I.B.F.—Box 860. Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY Manager requires position or as Assistant. Young, practical moulder, excellent experience in managerial positions on general engineering and also repetition work. Cupola control. Sound technical training.—Box 898, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Position as Foreman or Assistant. Experienced jobbing; repetition; high-duty and ordinary cast iron. Age 30. Guaranteed to get results.—Box 896, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SALESMAN wanted to sell insulation specialty. Reasonable salary and commission offered. Write stating connection, if any.—Box 900, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

TRAVELLER wanted with good connection, for special alloy steel castings, heat-resisting, stainless qualities, etc. Must have foundry experience. State age and salary.—Box 894, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Working Charge Hand Coremaker, capable of making and looking after high-class jobbing work.—RICHARDS (LEICESTER), LTD., Phœnix Iron Works, Leicester.

WANTED.—Metallurgical Chemist experienced in cast-iron work with foundry and blast-furnace experience, to take charge of laboratory. Write stating age, experience, and salary required, to Box 892, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

YOUNG Metallurgist requires situation. First-class experience, analysis of ferrous and non-ferrous metals, fuels, etc. Sand testing, mechanical testing, microscopic work. Works experience. Well trained technically. (286)

FINANCIAL

WANTED.—Interest in grey-iron and non-ferrous foundry, capable development. London district or 50 mile radius.—Box 872, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

BUSINESS FOR SALE

FOR SALE as a going concern, Modern Iron Foundry situated in North Lines, with a capacity of 50 tons per week. The foundry is equipped with one practically new Ultra Rapid Cupola by Alldays & Onions and one small cupola, one 5-ton overhead electric crane, 42 ft. span, and two moulding machines, one Jackman and one Darling & Sellers. Good stock of moulding boxes, two grinders, etc. Excellent river and railway transport.—Apply Box 882, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOR SALE OR TO LET

IRON FOUNDRY.—Well equipped and recently modernised, situated in the heart of an industrial area in the West Riding of Yorkshire, with a capacity of 30/40 tons per week. An appreciable volume of business is assured, and the proposition is an attractive one to the right people. Inspection invited.—Box 830, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C 2.

MACHINERY

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

Tilghman Sandblast Barrel Plants; barrel sizes—60 in. x 40 in.; 36 in. x 20 in.; 20 in. x 30 in.

Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.

All complete with Air Compressors, etc.

Gas and Air Mixer by Sharpe & Preston, 2-in. outlet.

Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.

Three Mumford Yoke Headpress Pneumatic Moulding Machines.

Two Herbert Whizzer Sand Disintegrators.

Two Brealey Type ditto.

Heavy Double-ended Grinding Machines by Rowlands, Luke & Spencer, etc.

Hand Moulding Machines by Adaptable Darling & Sellars, Pridmore, Samuelson, etc.

500 Electric Motors, Dynamos, Rotary Converters, etc.

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'Phone: Broadwell 1359.

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Inclining TUMBLING BARREL (Canning); 22" dia. barrel x 18" deep; 50 r.p.m. 12" dia. F. & L. pulleys.

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GALLOWAY BOILER; 18' 3" x 7' 6"; 80 lbs. w.p.

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MISCELLANEOUS

GENUINE Southport Wind Blown Sand, which makes best oil-sand cores. Prompt deliveries by road into works.

JOHN LIVESEY,
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MISCELLANEOUS—*Continued*

FLUIDITY TESTS as described in THE FOUNDRY TRADE JOURNAL, February 1, 1934. Patterns of the above in aluminium can be supplied for 35s. per set. Post free. We can also supply Patterns for all branches of the engineering trade, in hard or soft woods. Send us your inquiries. — FURMSTON & LAWLOR, Patternmakers, Letchworth, Herts.

'Phone: 287 SLOUGH

MOULDING MACHINES

Two Tabor Modern Jolt Squeeze and Pattern Draw Machines for boxes 20" × 14"; as new. Price £65 each.

One ditto, for 20" square Boxes. Price £70.

Several reconditioned GRIMES Hand Pattern-draw and Turnover Machines. Price £12 each.

One genuine OSBORN Hand Machine. Price £28.

Several nearly new DENBIGH Jolters. CHEAP!

CUPOLETTE, 30" dia., NEW. Price £26.

PLEASE SEND US YOUR ENQUIRIES.

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BUY FROM ME AND SAVE MONEY!

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